(15) AFRPL-TR-78-53

LEVEL II

(14) Acurex-UM-78-86 (72-

20000726127

(6) MOMENTUM/ENERGY INTEGRAL TECHNIQUE (MEIT) USER'S MANUAL

(10) K./Kwong, K./Suchstand H./Tong
Acurex Corporation/Aerotherm Div.
~~Aerospace Systems Division~~
485 Clyde Avenue
Mountain View, California 94042

(9) Rept. for Aug-31 Dec 77,

(11) July 1978

(12) 102 p.

Prepared for
Air Force Rocket Propulsion Laboratory
Director of Science and Technology
Air Force Systems Command, USAF
Edwards Air Force Base
California 93523

(15) Contract F04611-76-C-0075

(16) 3059 (17) 09

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise or in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

FOREWORD

This report was submitted by Acurex Corporation/Aerotherm Division, 485 Clyde Avenue, Mountain View California 94042, under Contract F04611-76-C-0075, Job Order No. 305909HM with the Air Force Rocket Propulsion Laboratory, Edwards AFB, California 93523.

The work documented in this report was performed as a result of a recommendation made in Volume II, Applicability of Reentry Technology to Rocket Nozzle Design, AFRPL-TR-77-78, which is an interim report of work performed under the above mentioned contract. The Aerotherm work was managed by Mr. Duane L. Baker, Program Manager, Aerospace Systems, and the Air Force Project Manager was Mr. William F. Payne.

This report has been reviewed by the Information Office/XOJ and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations. This technical report has been reviewed and is approved for publication; it is unclassified and suitable for general public release.

WILLIAM F. PAYNE, Project Manager

Dr. Clark Hawk
Acting Chief
Ballistic and Space Propulsion Branch

FOR THE COMMANDER

CHARLES R. COOKE, Director
Solid Rocket Division

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFRPL-TR-78-53	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Momentum/Energy Integral Technique (MEIT) User's Manual		5. TYPE OF REPORT & PERIOD COVERED August 1977 to 31 December 1977 6. PERFORMING ORG. REPORT NUMBER UM-78-86 (7257)
7. AUTHOR(s) K. Kwong, K. Suchsland, H. Tong		8. CONTRACT OR GRANT NUMBER(s) F04611-76-C-0075
9. PERFORMING ORGANIZATION NAME AND ADDRESS Acurex Corporation/Aerospace Systems Division 485 Clyde Avenue Mountain View, California 94042		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS JON 305909HM
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Rocket Propulsion Laboratory/AFSC Edwards Air Force Base, California 93523		12. REPORT DATE July 1978 13. NUMBER OF PAGES 129
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for public release; distribution unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Rocket Nozzle
Boundary Layer
Heat Transfer Coefficient
Numerical Solution
Roughness Heating
Integral Methods

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document presents a user's manual for the Momentum/Energy Integral Technique (MEIT) Computer Program, including a general description of the theory and solution procedure, the verification of the approach, as well as a detailed set of input instructions.

MEIT is a boundary layer integral code which solves both the integral momentum and energy equations to predict the heat transfer coefficient for

→over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

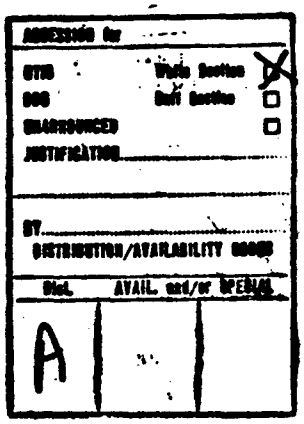
UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

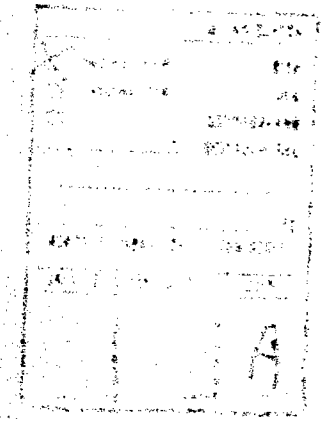
rocket nozzle environments.

A significant difference between MEIT and previous boundary layer codes is its ability to account for the effects of surface roughness.

TABLE OF CONTENTS



LIST OF ILLUSTRATIONS



LIST OF SYMBOLS

B'	blowing parameters, $\rho_w v_x / \rho_e u_e C_M$
c_p	specific heat at constant pressure
$C_f/2$	friction coefficient, $\tau_w / \rho_e u_e^2$
C_h	Stanton number, $\dot{q}_w / \rho_e u_e (h_r - h_w)$
f	transitional intermittency factor
F	recovery factor
h	enthalpy
h_r	recovery enthalpy
h_t	total enthalpy = $h + u^2/2$
H	shape factor, δ^*/θ
$I_{x,y,z}$	influence coefficient (Equation (20))
k	roughness height
p	pressure
Pr	Prandtl number
$\dot{q}_w$	wall heat flux
r	radial coordinate
R	Reynolds analogy factor $\equiv C_h/C_f/2$
s	stream length
T	temperature
u	streamwise velocity component
v	body normal velocity component
y	distance in surface normal direction, radial coordinate
γ	isentropic exponent, ratio of specific heats, c_p/c_v
δ^*	boundary layer displacement thickness

θ	boundary layer momentum thickness
$\lambda_{x,y}$	blowing reduction parameter
μ	viscosity
ν	kinematic viscosity, μ/ρ
ρ	density
ϕ	boundary layer energy thickness
τ	skin friction

Subscripts

e	boundary layer edge
∞	freestream
ℓ	laminar flow
t	turbulent flow
tr	transitional flow
w	wall

Superscripts

'	reference properties

SECTION 1

INTRODUCTION

In predicting rocket nozzle performance and analyzing Arc Plasma Generator (APG) data, the heat and mass transfer coefficient must be defined. In the past, the heat transfer coefficient has been calculated within Aerotherm by some boundary layer integral codes such as ARGEIBL (Reference 1) or BLIMP (Reference 2). Both of these computer codes assume that the boundary layer develops on a smooth wall. It has been shown (see Reference 3) that surface roughness developed in rocket nozzle and APG environments can cause substantial heat transfer augmentation. To account for this and other boundary layer effects, the Momentum/Energy Integral Technique (MEIT) computer program has been developed.

The MEIT methodology was originally developed to predict nosetip ablation on reentry vehicles. This methodology has been validated for reentry environment and is currently an important part of the ASC code (Reference 4). The methodology employed by MEIT solves both the integral momentum and energy equations. In addition, it utilizes heat transfer and skin friction laws based on the most recent roughness heating and friction data.

MEIT was developed from ASC by extracting all the subroutines that are related to the boundary layer calculation. Any nonapplicable subroutines, unnecessary variables and common block variables were deleted and a driver routine was written to read in all the required input. To tailor it for rocket nozzle applications, the input and output formats were modified so that they are compatible with the usage requirements of rocket nozzle designers.

MEIT was verified by comparing solutions to solutions generated by ARGEIBL and BLIMP. Solutions from the TBL code (Reference 5) which is developed by Pratt and Whitney Aircraft Company, were also used. Both smooth and rough wall solutions were considered in the MEIT checkout. Like ARGEIBL and other integral techniques, the heat transfer coefficient generated by MEIT must be decreased by 25 percent.

In Section 2, a brief description of the MEIT methodology is presented. This is followed by the verification of MEIT in Section 3. Section 4 provides the input and output formats and Section 5 presents two sample problems. A listing of the program is given in Section 6.

SECTION 2

MEIT METHODOLOGY

The MEIT methodology was originally developed to predict nosetip ablation in reentry vehicles. A detailed description of the methodology is given in Reference 6. Only the essential information will be presented in Section 2.

The MEIT methodology solves both the boundary layer integral momentum and energy equations. The required input are surface shape, boundary layer edge conditions, boundary layer gas properties and wall conditions (see Section 4). To solve these two equations, the local shape factor, recovery factor, Stanton number and friction coefficient must be defined. The effects of surface roughness, transpiration, acceleration, and boundary layer properties are taken into account in terms of influence coefficients. These influence coefficients are included in the formulation of both the local Stanton number and friction coefficient. The solution procedure is carried out by an implicit finite difference scheme. Although MEIT is designed primarily for rocket nozzle environment, which consists of turbulent flow; both laminar and transitional flow situations are also included.

In Section 2.1, the basic equations are presented. This is followed by the formulation of local shape factor, recovery factor, Stanton number, and friction coefficient in Section 2.2 The solution procedure is described in Section 2.3.

2.1 BASIC EQUATIONS

The two boundary layer integral equations solved by MEIT are:

Integral momentum equation

$$\frac{1}{r\rho_e u_e^2}\frac{d}{ds}\left(r\rho_e u_e \theta\right) = \frac{C_f}{2} + \frac{(\rho v)_w u_e}{\rho_e u_e^2} + \frac{H\theta}{\rho_e u_e^2}\frac{dp}{ds} \tag{1}$$

Integral energy equation

$$\frac{1}{r\rho_e u_e (h_{t,e} - h_w)}\frac{d}{ds}\left(r\rho_e u_e (h_{t,e} - h_w)\phi\right) = C_h\left(\frac{h_r - h_w}{h_{t,e} - h_w}\right) + \frac{(\rho v)_w (h_{t,e} - h_w)}{\rho_e u_e (h_{t,e} - h_w)} \tag{2}$$

where the momentum and energy thicknesses are respectively:

$$\theta \equiv \int_0^\infty \frac{\rho u}{\rho_e u_e}\left(\frac{u_e - u}{u_e}\right) dy \tag{3}$$

$$\phi \equiv \int_0^\infty \frac{\rho u}{\rho_e u_e}\left(\frac{h_{t,e} - h_t}{h_{t,e} - h_w}\right) dy \tag{4}$$

The boundary layer shape factor, H, is defined as:

$$H = \frac{\delta^*}{\theta} \tag{5}$$

where δ^*, the displacement thickness is given by:

$$\delta^* = \int_0^\infty \left(1 - \frac{\rho u}{\rho_e u_e}\right) dy \tag{6}$$

The total enthalpy at the boundary layer edge is defined by

$$h_{t,e} = h_e + \frac{u_e^2}{2} \tag{7}$$

while the recovery enthalpy is given by

$$h_r = h_e + F\frac{u_e^2}{2} \tag{8}$$

where F is the recovery factor.

The heat transfer rate and skin friction are related to the Stanton number and friction coefficient respectively by:

$$\tau_w = \rho_e u_e^2 \frac{C_f}{2} \tag{9}$$

$$\dot{q}_w = \rho_e u_e C_H (h_r - h_w) \tag{10}$$

In order to facilitate the solutions of equations (1) and (2), besides the required input of surface shape, boundary layer edge conditions, boundary layer gas properties, and wall conditions, the local shape factor, recovery factor, Stanton number and friction coefficient have to be formulated.

2.2 SHAPE FACTOR, RECOVERY FACTOR, STANTON NUMBER AND FRICTION COEFFICIENT

The shape and recovery factors are evaluated in MEIT by the following relations.

For laminar flow:

$$H_\ell = 3.029\frac{T_w}{T_e} - 0.614 \tag{11}$$

$$F_\ell = Pr^{\frac{1}{2}} \tag{12}$$

For turbulent flow:

$$H_t = 2.285\,(1 + 3.2e^{-n})\frac{T_w}{T_e} - 0.96 \tag{13}$$

$$F_t = Pr^{1/3} \tag{14}$$

where n, the turbulent velocity profile exponent, is given by:

$$n = \frac{0.37 + \ell n\, Re_\theta}{2.79 - 0.14\,\ell n\, Re_\theta} \tag{15}$$

The friction coefficient and the Stanton number are evaluated by the basic wall shear and heat flux laws respectively. Both of these laws are based on incompressible flow along a smooth, isothermal, impervious, flat plate. The friction coefficient and Stanton number are:

for laminar flow

$$\frac{C_{f,\ell,o}}{2} = \frac{0.245}{Re_\theta} \tag{16}$$

$$C_{h,\ell,o} = \frac{0.22}{Pr^{4/3}\, Re_\phi} \tag{17}$$

And for turbulent flow

$$\frac{C_{f,t,o}}{2} = \frac{0.245}{Re_\theta} + \frac{0.0123\, Re_\theta}{100 + Re_\theta} (\log_{10} Re_\theta)^{-1.6} \tag{18}$$

$$C_{h,t,o} = \frac{0.22}{Pr^{4/3} Re_\phi} + \frac{0.0123\, Re_\phi}{Pr^{1/2}\,(100 + Re_\phi)} (\log_{10} Re_\phi)^{-1.6} \tag{19}$$

In order to account for the various boundary layer effects, the Stanton number and friction coefficient given above are modified by the corresponding influence coefficients:

$$C_{x,y} = C_{x,y,o} \prod^{z} I_{x,y,z} \qquad \text{for } \begin{matrix} x = h,f \\ y = \ell,t \end{matrix} \tag{20}$$

The influence coefficients are shown by $I_{x,y,z}$ where the subscripts x and y indicate whether the influence coefficient pertains to heat or momentum transfer (x = h or f) and laminar or turbulent flow (y = ℓ or t), respectively. The subscript z indicates the type of phenomenon for which the basic laws are being modified.

Four phenomena are considered by MEIT. These phenomena and their corresponding z-subscripts are given in Table 1. The influence coefficients corresponding to each of these effects are formulated below.

TABLE 1

Phenomena	z-subscript of influence coefficient
acceleration	β
transpiration	B'
boundary layer properties	p
roughness	r

Acceleration

In laminar flow,

$$I_{f,\ell,\beta} = (1 + 3\beta)^{1/3}, \quad \beta > 0$$

$$I_{f,\ell\,\beta} = 1.0, \quad \beta < 0$$

$$I_{h,\ell,\beta} = (1 + 4\beta)^{1/6}, \quad \beta > 0$$

$$I_{h,\ell,\beta} = 1.0, \quad \beta < 0$$

where: $\beta \equiv \frac{2\xi}{u_e} \frac{du_e}{d\xi}$

$$\xi \equiv \int_0^s \rho_e \mu_e u_e r^2 \, ds$$

In turbulent flow, only the first terms of the appropriate basic turbulent laws are modified by the above influence coefficients.

Transpiration

Blowing effects are modeled with adaptations to film theory (Reference 7).

$$I_{h,y,B'} = \frac{\ell n(1 + 2\lambda_{h,y} R'B')}{2\lambda_{h,y} R'B'}, \quad y = \ell,t$$

$$I_{f,y,B'} = \frac{\ell n(1 + 2\lambda_{f,y} R'RB')}{2\lambda_{f,y} RR'B'}, \quad y = \ell,t$$

where: $R \equiv {}^{C_h}/_{C_f/2}$ = Reynolds Analogy Factor

R' = Mass to heat transfer coefficient ratio

$\lambda_{x,y}$ = Blowing reduction parameter.

R is a dependent variable which is evaluated during the solution process. Both R' and $\lambda_{x,y}$ are input (see Section 4). MEIT, however, does provide build-in default values for $\lambda_{x,y}$. These default values are:

$$\lambda_{h,\ell} = \lambda_{f,\ell} = 0.5$$

$$\lambda_{h,t} = \lambda_{f,t} = 0.35$$

Boundary Layer Properties

Boundary layer properties of density, viscosity, and Prandtl number are evaluated at the reference enthalpy h'

$$h' = ah_e + bh_r + ch_w$$

The property influence coefficients are:

$$I_{x,y,p} = \left(\frac{\rho'}{\rho_e}\right)^d \left(\frac{\mu'}{\mu_e}\right)^e, \quad x = f,h; \quad y = \ell,t$$

where the constants a, b, c, d, and e for all combinations of x and y are given in Table 2.

TABLE 2

Constants Used to Evaluate Property Influence Coefficients

Property influence coefficients	Constant				
	a	b	c	d	e
$I_{f,\ell,p}$	0.23	0.19	0.58	0	0
$I_{h,\ell,p}$	0.23	0.19	0.58	1	1
$I_{f,t,p}$	0.36	0.19	0.45	1	0.25
$I_{h,t,p}$	0.36	0.19	0.45	1	0.25

Surface Roughness

In laminal flow,

$$I_{h,\ell,r} = I_{f,\ell,r} = 1$$

In turbulent flow, the influence coefficient due to surface roughness is based on correlations from PANT and Stanford heat transfer data (Reference 8 and 9), as well as Stanford and NSWC friction data (Reference 9 and 10). The turbulent influence coefficients due to roughness are:

$$I_{f,t,r} = 1 + 0.5\, f(k/\theta)\, g(X)$$

$$I_{h,t,r} = 1 + 0.3\, f(k/\theta)\, g(X)$$

where: $f(k/\theta) = 1 + 0.09\,(k/\theta) + 0.53\,(1-e^{-k/\theta})$

$$g(X) = X + 1.5\,(1-e^{-X}) \qquad \text{for } X > 0$$

$$= 0 \qquad \text{for } X \leq 0$$

$$X = \log \frac{k^+}{15.5}$$

$$K^+ = \frac{\rho_e u_e k}{\mu_e} \frac{\mu_e}{\mu_w} \left(\frac{\rho_w}{\rho_e}\right)^{1/2} \sqrt{\frac{C_{f,t,s}}{2}}$$

$C_{f,t,s}$ = smooth wall friction coefficient given by equation (19)

k = surface roughness

k is input either as function of material or location (see Section 4).

The above formulations for H, F, C_h, $C_{f/2}$ are only for laminar and turbulent flows. To evaluate these four parameters for transitional flow the following relation is used:

$$P = (1 - f) P_\ell + f P_t \qquad (21)$$

where P is one of the four parameters above and f is the transitional intermittency factor.

The transitional intermittency employed in MEIT is based on the work of Persh (Reference 11), and according to the interpretation of Dahm (Reference 12).

$$f = 1 - \frac{\alpha}{Re_\theta^2 (C_{f,t} - C_{f,\ell})}$$

where $$\alpha = Re_{\theta,tr}^2 (C_{f,t} - C_{f,\ell})_{tr}$$

and the subscript tr refers to conditions at the transition point.

f is set to zero in laminar flow, unity in turbulent flow, and varies between 0 and 1 in transitional flow.

This completes the formulation of the four required parameters used in the solutions of equations (1) and (2).

2.3 SOLUTIONS OF BOUNDARY LAYER INTEGRAL EQUATIONS

As mentioned above, the required input to MEIT are surface shape, boundary layer edge conditions, boundary layer gas properties, and wall conditions. These quantities are input in terms of body points. A finer grid in terms of integration points, which include all the body points, is generated by the program to ensure adequate solution accuracy of the integral equations. The boundary layer edge conditions, gas properties and wall conditions at each integration point are obtained by linear interpolation from the input. The solution procedures of the boundary layer integral equations (1) and (2) consist of:

- start-up series solutions at the first three integration points
- finite difference numerical solutions for the rest of the integration points

The solutions at the first integration point are given by:

$$\theta_1 = \sqrt{\frac{0.245\ \nu_1\ (1 + R_1 B_1')}{(3 + H)\left.\frac{du_e}{ds}\right|_1}}\ \prod_{1}^{z} C_{f,\ell,z}$$

$$\phi_1 = \sqrt{\frac{0.22\ \nu_1\ (1 + B_1')}{2\ Pr^{w3}\left.\frac{du_e}{ds}\right|_1}}\ \prod_{1}^{z} C_{h,\ell,z}$$

The solutions at the second and third integration point are related to the first integration point by:

$$\theta = \theta_1\ (1 + a\psi^2)$$

$$\phi = \phi_1\ (1 + b\psi^2)$$

where: $$a = \frac{\frac{13 + H_1}{4}\frac{\alpha}{\gamma} + \frac{1}{3} - \frac{0.659\ (3 + H_1)\ \alpha\ (\gamma-1)}{\gamma} - \frac{(H_1-0.614)\ \alpha\ (\gamma-1)}{\gamma}}{8 + 2H_1}$$

$$b = \frac{1}{6}\left[\frac{3\alpha}{\gamma} + \frac{1}{3} - \frac{2 \times 0.659\ \alpha\ (\gamma-1)}{\gamma} - \frac{2(1-F_\ell)(1+B')\ \alpha(\gamma-1)}{(1 - T_w/T_1)\gamma}\right]$$

$$\psi = s/R_{ref}$$

and $$\alpha = \frac{1 - (p_3/p_1)}{\psi_3^2}$$

In the above formulation, R_{ref} is an arbitrary constant radius and γ is the isentropic exponent. The subscripts 1 and 3 denote the first and third integration point condition respectively.

The solutions of the first three integration points were originally derived for reentry nosetip ablation prediction, and consider the first integration point to be a stagnation point. In MEIT, these solutions serve only as the start up procedure and should be ignored in the output.

For the rest of the integration points, the following implicit finite difference scheme is used:

$$F_{x,I} = F_{x,I-1} + 0.5(F'_{x,I-1} + F'_{x,I})(s_I - s_{I-1}) \qquad x = f,h$$

where: $F_f = r\ \rho_e u_e{}^2 \theta$ (see Equation (1))

$F_h = r\ \rho_e u_e (h_{t,e} - h_w)\phi$ (see Equation (2))

$$F'_f = \frac{dF_f}{ds}$$

$$F'_h = \frac{dF_h}{ds}$$

I is the integration point index and F'_f and F'_h are both evaluated from equation (1) and (2) respectively.

Since the values of $F_{x,I}$ depend on $F'_{x,I}$, the solution is obtained by iteration. This iteration is local because closure is obtained at each integration point before proceeding down the body to the next integration point. Convergence is based on changes of less than 0.1 percent in both the heat and momentum transfer coefficients between successive iterations. If the iteration fails to converge in 30 tries, a local explicit solution is obtained by setting $F'_{x,I} = F'_{x,I-1}$, and subsequently reevaluating $F'_{x,I}$ based on the resulting value of $F_{x,I}$, before proceeding to tne next integration point.

SECTION 3

VERIFICATION OF MEIT

Three computer programs were used in the check out of MEIT. These three codes are:

- ARGEIBL
- BLIMP
- TBL

Both ARGEIBL and BLIMP have no provisions to account for surface roughness. ARGEIBL solves only the energy integral equation and the heat transfer coefficients it calculates are routinely multiplied by 0.75 to improve their accuracy. BLIMP uses an exact implicit technique to solve the boundary layer differential conservation equations. The solution from BLIMP is believed to be the most accurate of these codes and was used as the primary criterion to determine the validity of MEIT in the check out. TBL is developed by Pratt and Whitney Aircraft Company and, like MEIT, it uses both the momentum and energy integral equations to calculate the Stanton number. It also has build-in routines to account for surface roughness.

The check out is performed by generating and comparing heat transfer coefficients for two typical rocket nozzle environments using these four computer codes. The selected rocket nozzle environments are the Aerojet MX upper stage and the C/CAN nozzle. The results of the check out and the conclusions and recommandations are summarized below.

3.1 AEROJET MX UPPER STAGE NOZZLE

An analysis of the Aerojet MX upper stage nozzle by BLIMP, ARGEIBL, and MEIT as used to validate MEIT. The geometry of the nozzle is shown

in Figure 1. A listing of the nozzle wall coordinates is given in Table 3. The nozzle has a 3.146-inch radius throat and it uses a PEG/FEFO propellant. The elemental composition of the propellant and the associated chamber conditions are given in Table 4. All this information was obtained from Reference 13. The edge conditions were calculated by the ACE code (Reference 14), and the results in terms of edge pressure, temperature, enthalpy, and velocity are presented in Figure 2. The nozzle radius is plotted as a function of stream length in Figure 3. A wall temperature of 5500°R was used in all the following calculations.

Smooth wall solutions were obtained using MEIT, ARGEIBL, and BLIMP, and the heat transfer coefficients from these solutions are compared in Figure 4. The MEIT and ARGEIBL solutions are very close to each other for regions downstream of the throat. Both of these solutions are high compared to BLIMP results. As mentioned above, the ARGEIBL solution must be reduced by a 0.75 factor to accurately predict the heat transfer coefficient. Using 0.75 as the modifier, the modified MEIT and ARGEIBL solutions are again compared to the BLIMP solution in Figure 5. From this figure, it can be seen that both the reduced MEIT and ARGEIBL solutions compare much better with the BLIMP solution. This shows that MEIT, like ARGEIBL, requires a modifier of 0.75.

For the unblown, smooth wall and turbulent flow calculations (as in the above case) it can be shown from Section 1 and Reference 1 that MEIT is solving the same Energy Integral Equation as in ARGEIBL (i.e., for this case the Momentum Integral Equation does not enter into the solution process). It is therefore of interest to find out the reasons for the difference in the MEIT and ARGEIBL heat transfer coefficient solutions. The chief reason is the different formulation for the local Stanton number in the two codes. In MEIT, the local Stanton number is given by equation (19)

$$C_{h,t,o} = \left[\frac{0.22}{Pr^{2/3}\, Re_\phi} + \frac{0.0123\, Re\theta}{Pr^{1/2}\,(100 + Re_\phi)} (\log Re_\phi)^{-1.6}\right]$$

and modified by the influence coefficients due to acceleration and boundary layer properties. In ARGEIBL, the Stanton number is defined by:

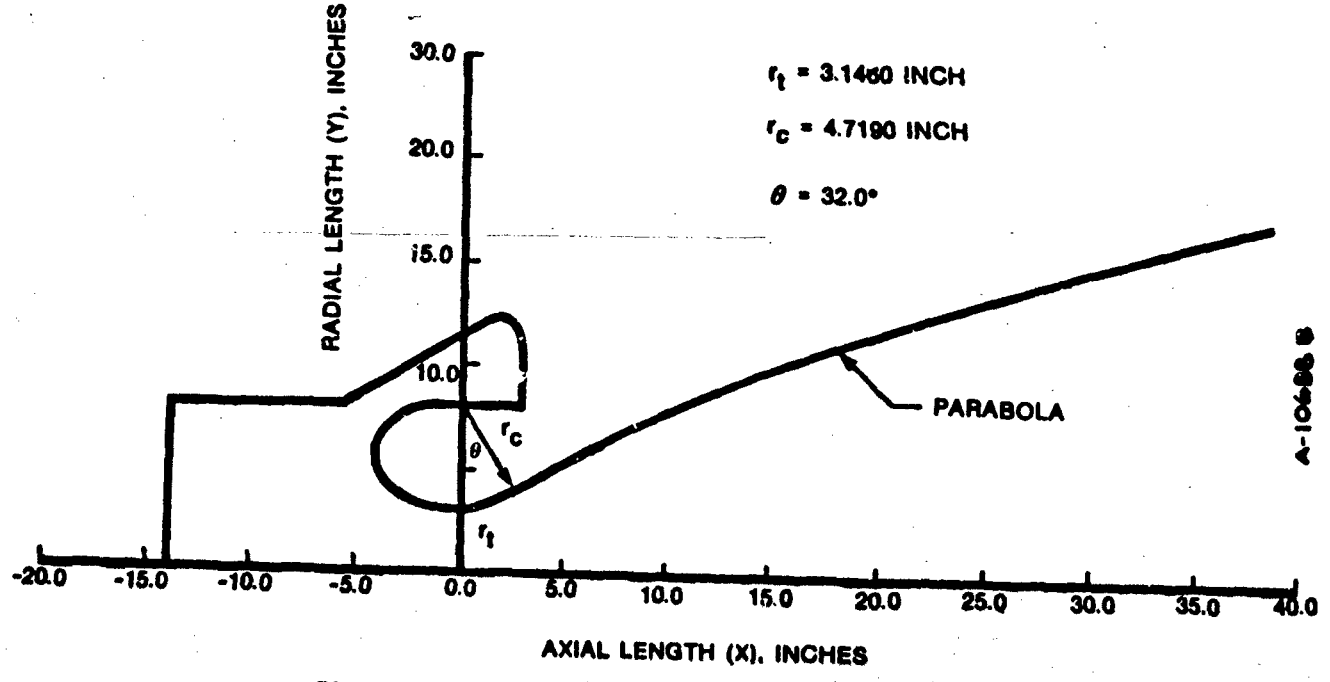


Figure 1. Geometry of the Aerojet MX upper stage nozzle.

TABLE 3. WALL COORDINATES OF THE AEROJET MX UPPER STAGE NOZZLE

X, IN.	Y, IN.	
-4.00	5.40	NOSE CAP
-3.89	4.96	
-3.72	4.67	
-3.54	4.44	
-3.30	4.25	
-3.04	4.02	
-2.76	3.83	
02.38	3.65	
02.08	3.52	
-1.70	3.39	
-1.32	3.30	
-0.94	3.22	
-0.58	3.19	
-0.20	3.147	
0	3.146	THROAT
0.165	3.149	
0.411	3.164	
0.657	3.19	
1.06	3.27	
1.45	3.38	
1.99	3.588	
2.36	3.78	
3.62	4.54	
7.53	6.64	
10.32	7.95	
14.89	9.87	
20.43	..93	
25.20	13.5	
30.60	15.2	
38.60	17.5	EXIT

TABLE 4. PEG/FEFO PROPELLANT DATA

$P_{CHAMBER}$ = 102. ATM

$T_{CHAMBER}$ = 6912. °R

ELEMENTAL COMPOSITION

ELEMENT	GM ATOMS / 100 GRAMS
H	2.39527
C	1.13509
N	1.79248
O	2.27887
F	0.07275
Al	0.68563
Cl	0.07071

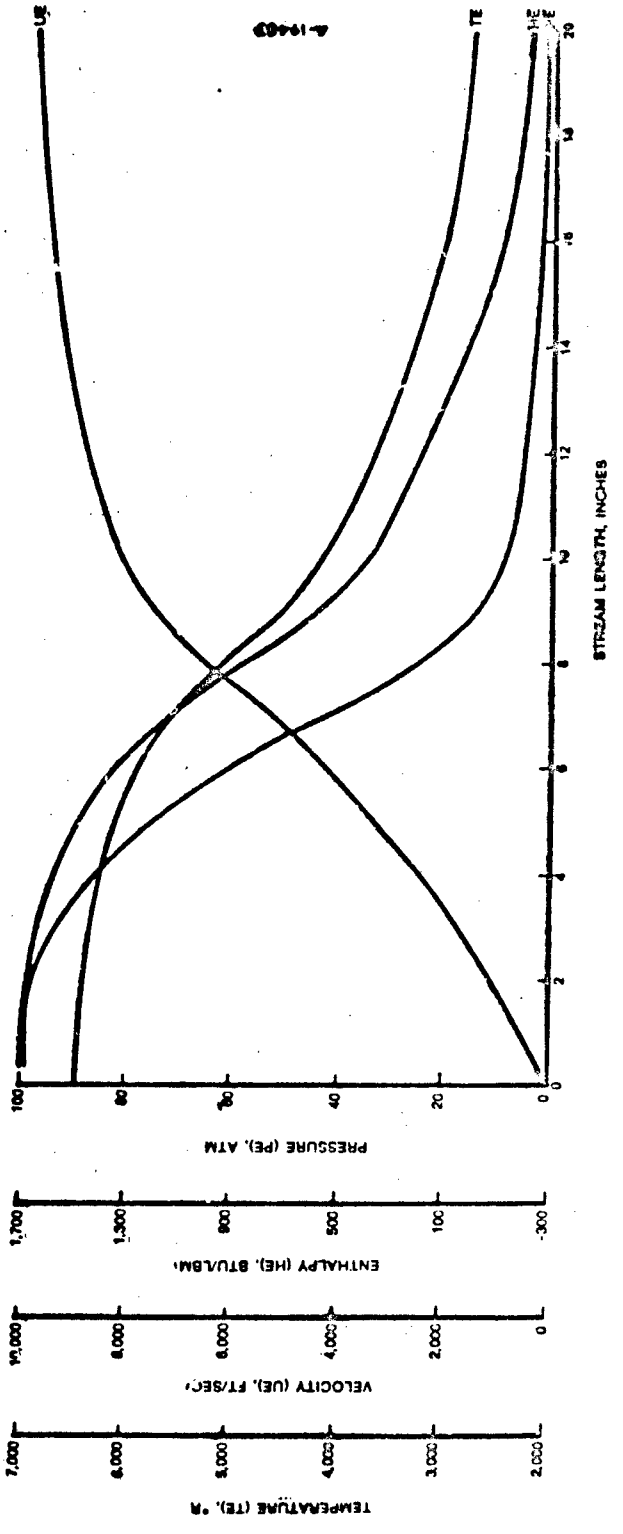


Figure 2. Edge conditions of the Aerojet MX upper stage nozzle.

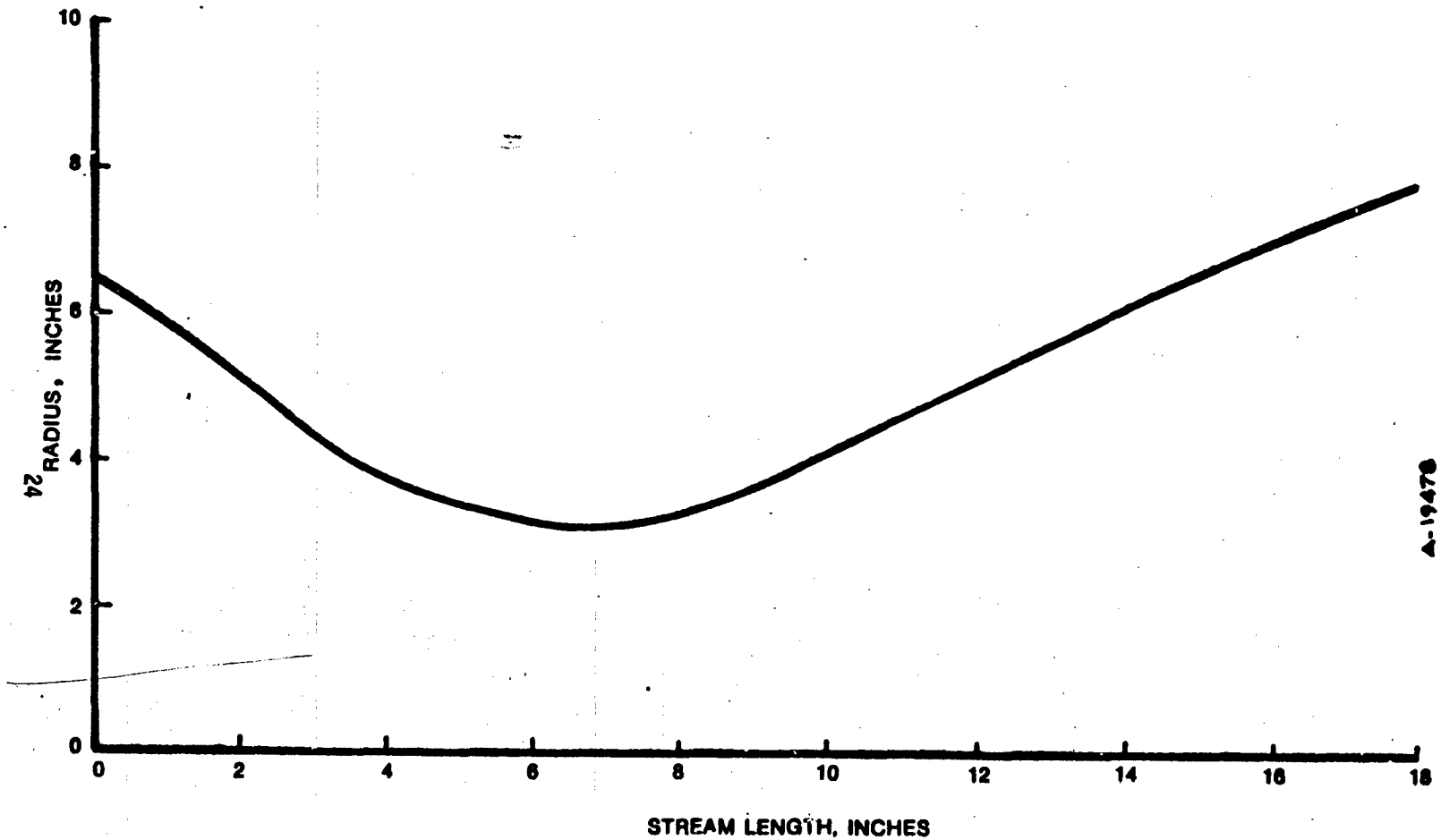


Figure 3. Nozzle radius vs. stream length for the Aerojet MX upper stage nozzle.

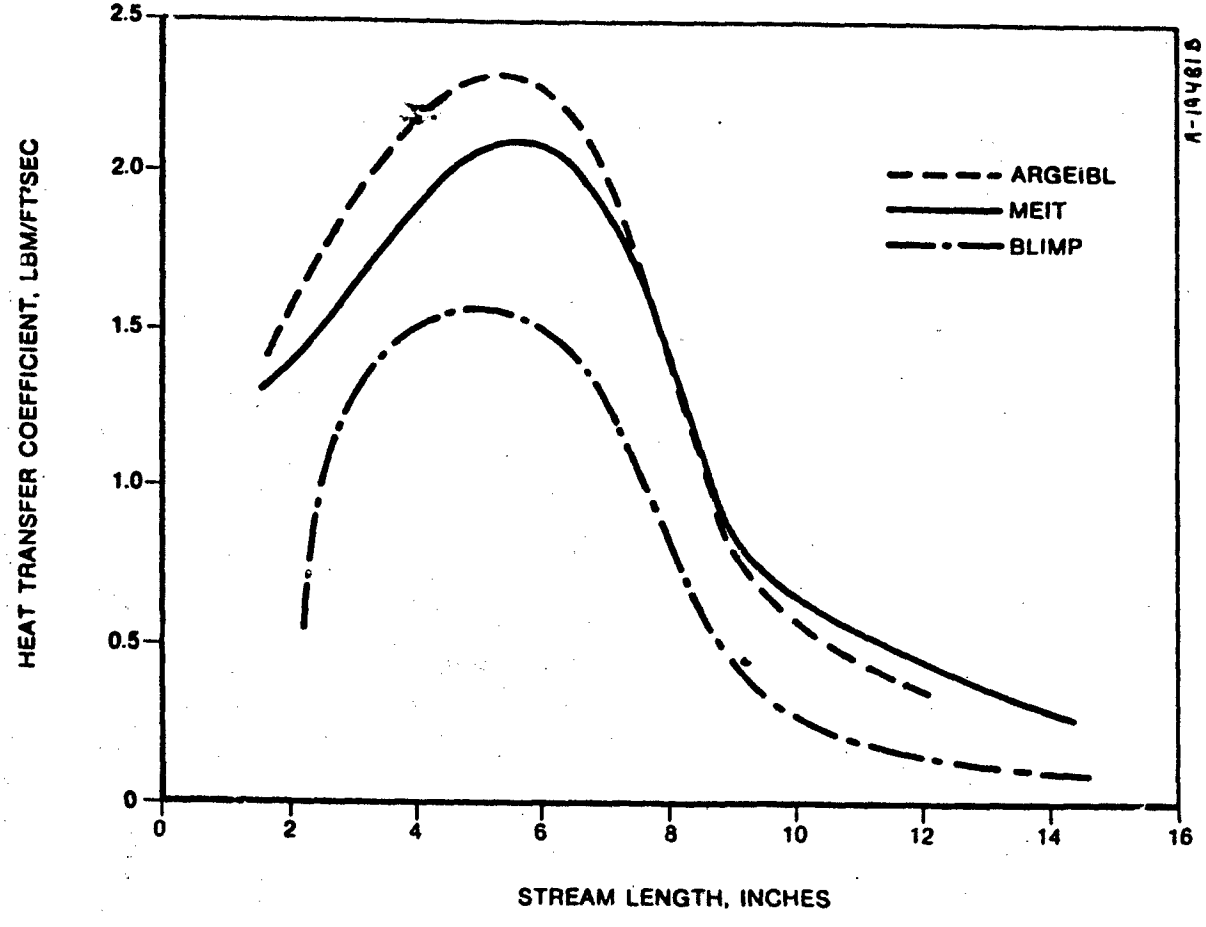


Figure 4. Heat transfer coefficient for the Aerojet MX upper stage nozzle.

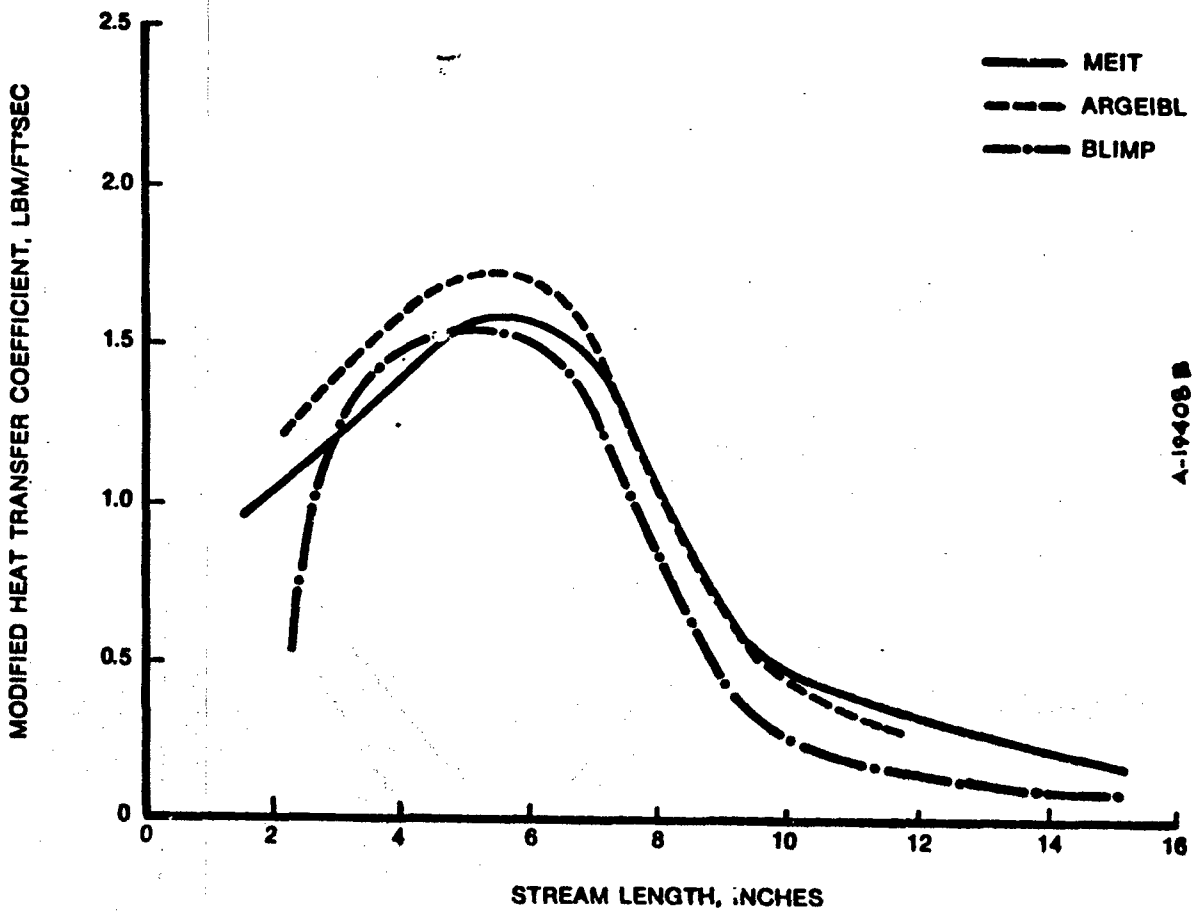


Figure 5. Modified heat transfer coefficient for the Aerojet MX upper stage nozzle.

$$C_h = \frac{0.0130 \left(\frac{\rho'}{\rho}\right)^{1/4}}{(Pr')^{3/6}\ Re^{1/4}}$$

where the subscript ' denotes properties evaluated at the reference enthalpy.

Other reasons are differences in the subroutines built in each code. These are the following:

- ARGEIBL uses the trapezoidal rule to calculate the numerical integration whereas MEIT uses an averaging technique.
- ARGEIBL uses a cubic curve fit to interpolate the required properties whereas MEIT uses a linear interpolation.

To check if MEIT is indeed solving the same energy integral equation as in ARGEIBL for the unblown, smooth wall and turbulent flow calculation, the Stanton number formulation in MEIT was replaced by the ARGEIBL formulation, and a solution was obtained using this new 'ARGEIBL-MEIT' code. The heat transfer coefficients from this calculation are again compared to those given by ARGEIBL in Figure 6. The two solutions compare very well in the nose cap region and the differences in other locations are basically due to the different inherent routines mentioned above.

In order to check the surface roughness formulation, a rough wall solution was generated by MEIT. A roughness height of 2 mil was used throughout the nozzle. The roughness augmentation from this calculation is compared to those given in Reference 15 in Figure 7. The results from Reference 15 are based on local energy thickness and conditions given by the smooth wall BLIMP solution and were hand-calculated using the MEIT surface roughness formulation. Figure 7 shows that these two solutions compare very well with each other. The higher values given by Reference 15 are mainly due to the use of smooth wall momentum thicknesses in the hand calculation.

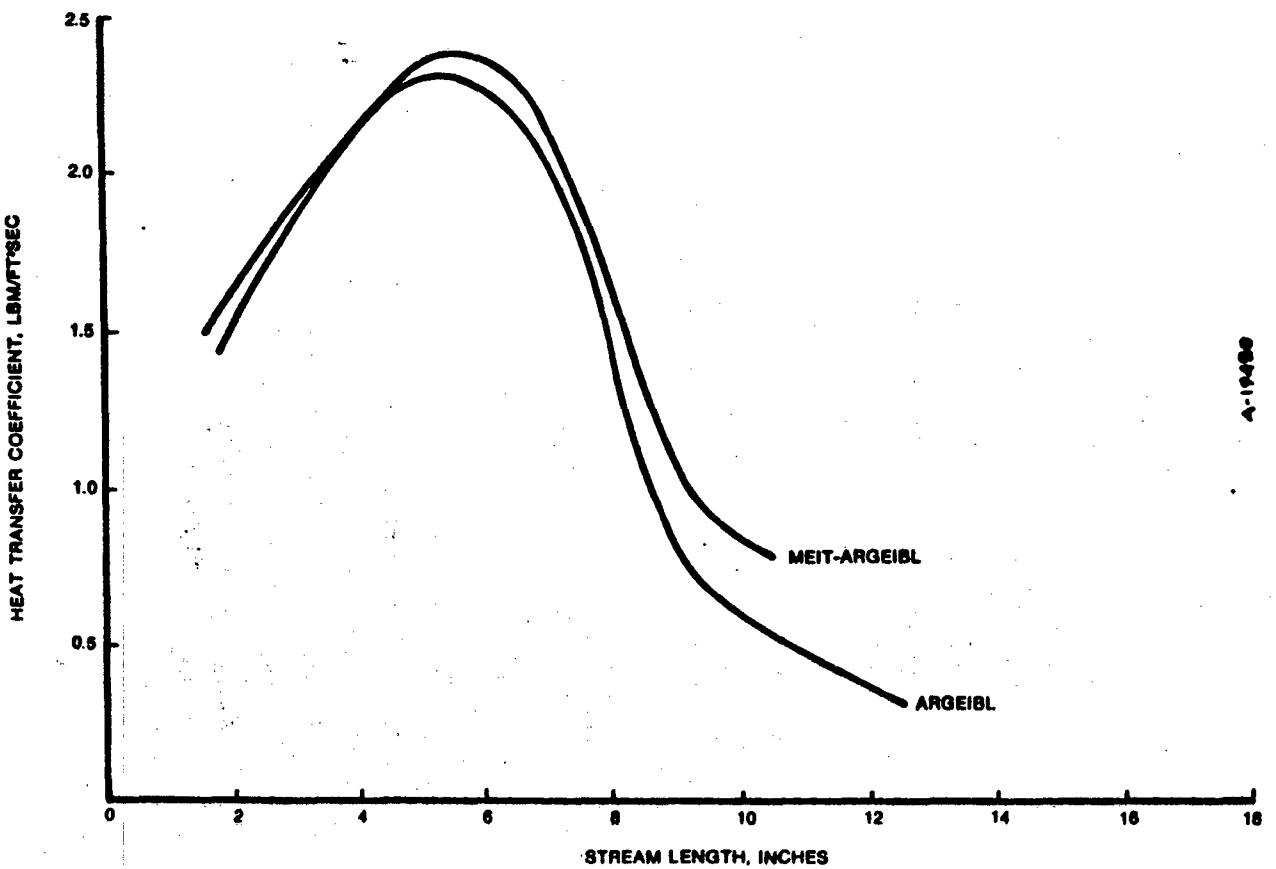


Figure 6. Heat transfer coefficient for the Aerojet MX upper stage nozzle.

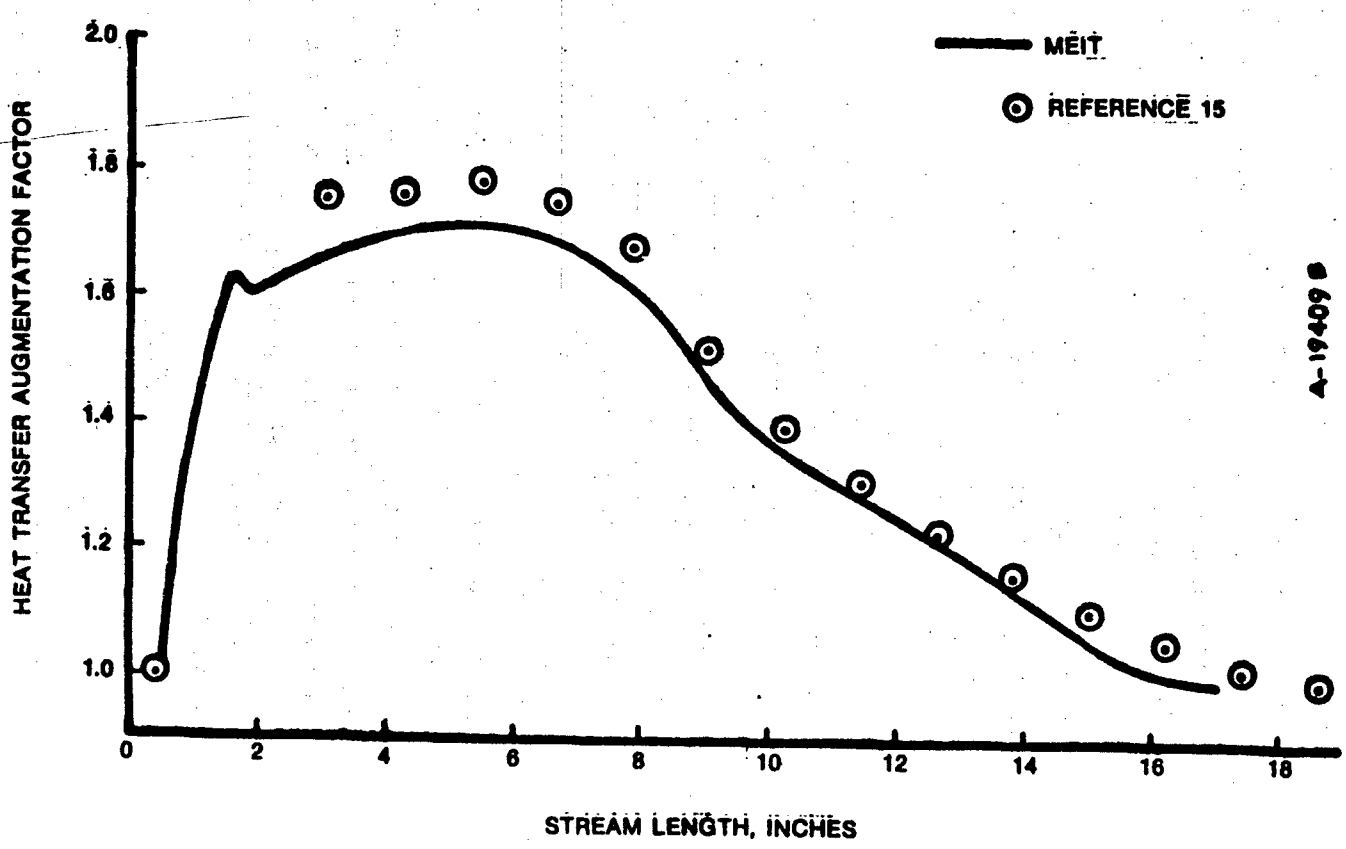


Figure 7. Predicted heat transfer augmentation factor for the Aerojet MX upper stage nozzle.

3.2 C/CAN NOZZLE

The C/CAN nozzle is used primarily to compare the rough wall solutions generated by MEIT and TBL. The geometry of the nozzle is shown in Figure 8. A listing of the wall coordinates of the nozzle is given in Table 5. The nozzle has a throat radius of 0.960 inch and uses a HT 90/18 propellant. The elemental composition of the propellant and the chamber conditions are given in Table 6. The above information was obtained from Reference 16. The edge conditions were again calculated by ACE and are presented in Figure 9. The nozzle radius vs. stream length plot is given in Figure 10 and the wall temperature is assumed to be 4939°R.

Both smooth and rough wall calculations were performed by MEIT Smooth and rough wall solutions generated by TBL were furnished to Aerotherm by Atlantic Research Corporation (Reference 16). The rough wall calculations were based on a roughness height of 2 mil. The solutions are compared in Figure 11. For the smooth wall case, the MEIT and TBL solutions are almost identical. For the rough wall case, MEIT predicts lower heat transfer coefficients than TBL except for locations just downstream of the combustion chamber. According to Reference 16, the TBL solutions, like those generated by ARGEIBL, are normally modified by modifying factors to make them compatible with measured values. These modifying factors are developed from actual motor firing data. However, since there were no firing data available at the time of the check out, the question of whether MEIT or TBL is more accurate in rough wall prediction cannot be answered at this time.

Reference 16 also indicates that the roughness modelling in TBL would not approach the smooth wall modelling when the surface roughness is reduced. To make sure that this is not the case for MEIT, an additional MEIT calculation was performed using a roughness height of 0.01 mil. The results are exactly the same as the smooth wall solutions shown in Figure 11. This indicates that MEIT is self-consistent.

3.3 CONCLUSIONS AND RECOMMENDATIONS

The findings and conclusions based on the above discussion are summarized below:

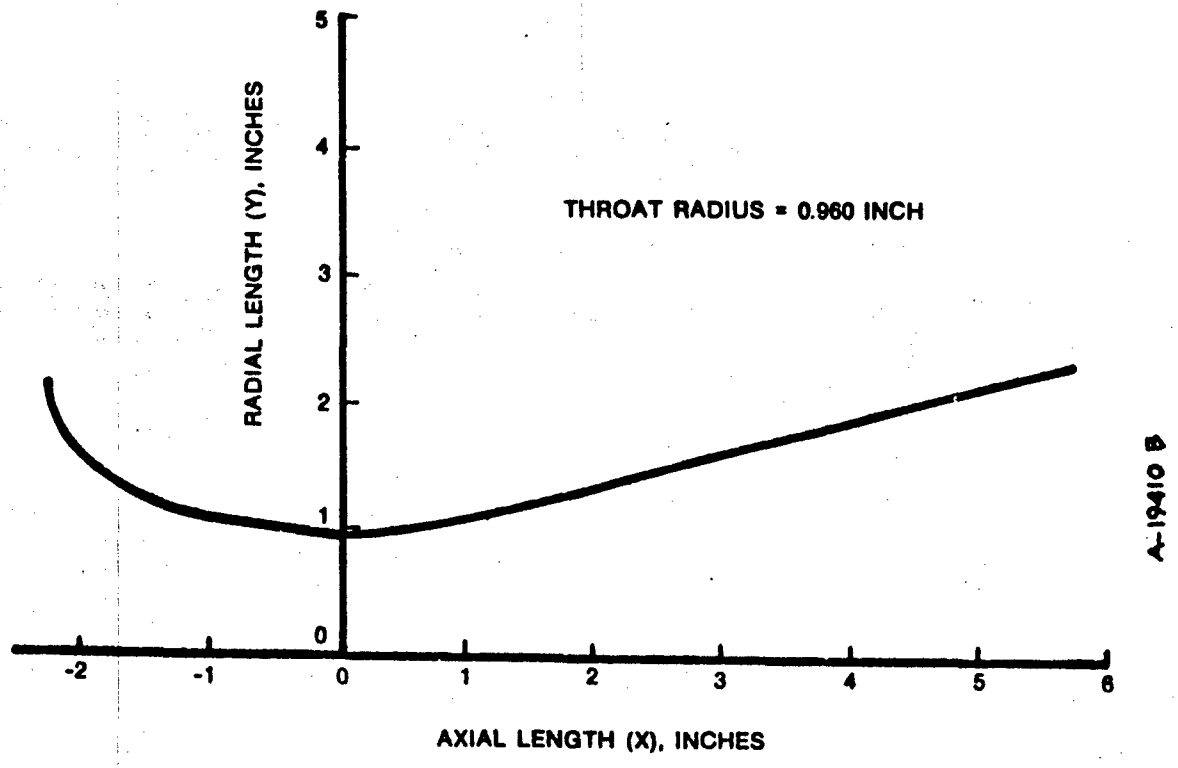


Figure 8. Geometry of the C/CAN nozzle.

TABLE 5. WALL COORDINATES OF THE C/CAN NOZZLE

X, IN.	Y, IN.	
-2.25	2.12	NOSE CAP
-2.20	1.836	
-2.0	1.526	
-1.85	1.410	
-1.50	1.252	
-1.10	1.114	
-0.80	1.041	
-0.54	0.991	
-0.30	0.971	
-0.10	0.961	
0.0	0.960	THROAT
0.10	0.961	
0.20	0.965	
0.40	0.980	
0.60	1.005	
0.80	1.041	
1.20	1.141	
1.70	1.275	
2.45	1.475	
3.45	1.743	
4.45	2.011	
5.70	2.346	

TABLE 6. HT 90/18 PROPELLANT DATA

$P_{Chamber}$ = 68.027 atm

$T_{Chamber}$ = 6627.6 °R

$H_{Chamber}$ = - 812.70 Btu/lbm

ELEMENTAL COMPOSITION:

Element	Gm Atoms / 100 gram
H	3.4976
C	.6936
N	.6177
O	2.4857
Al	.6671
Cl	.6128

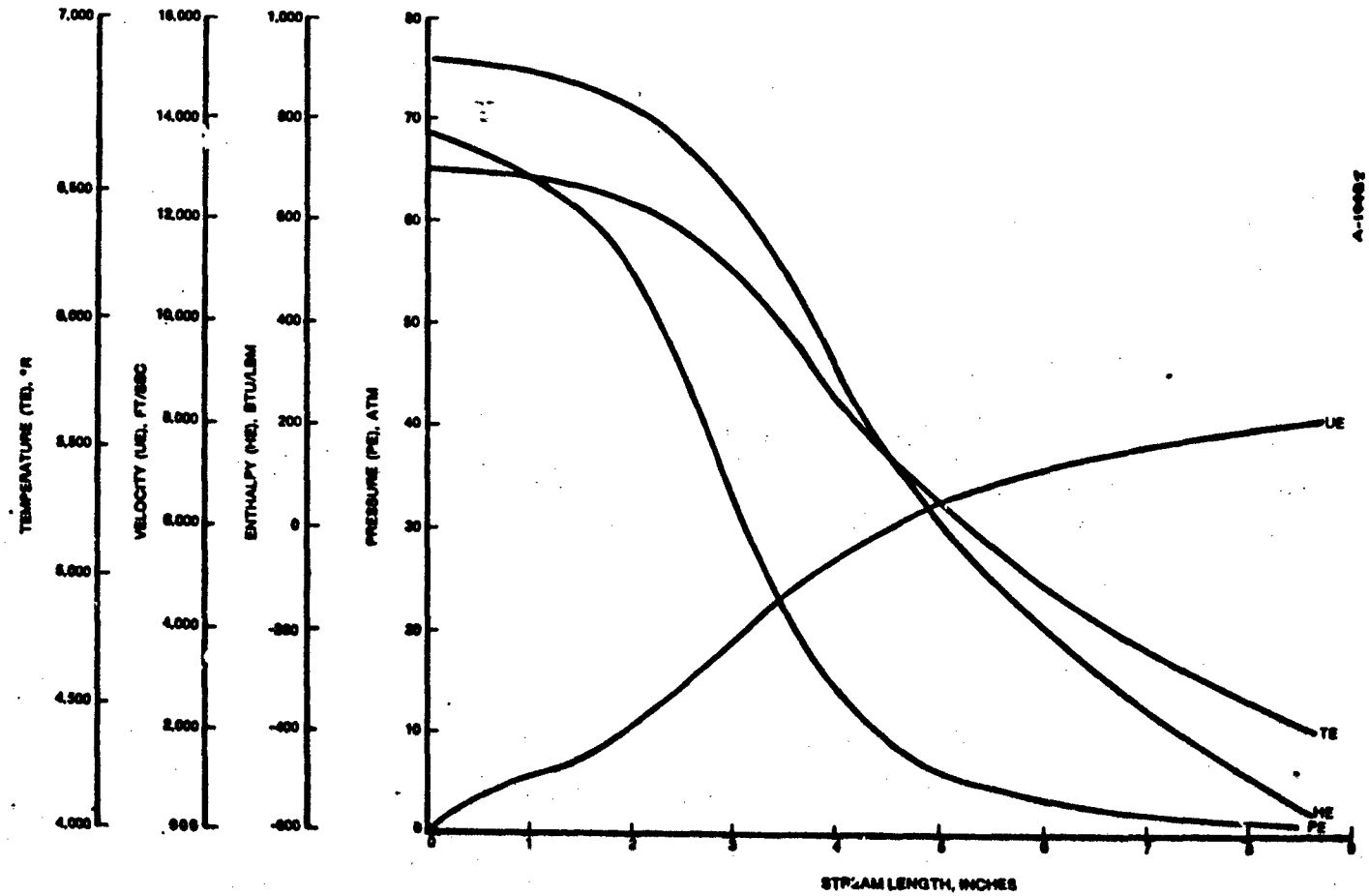


Figure 9. Edge conditions of the C/CAN nozzle.

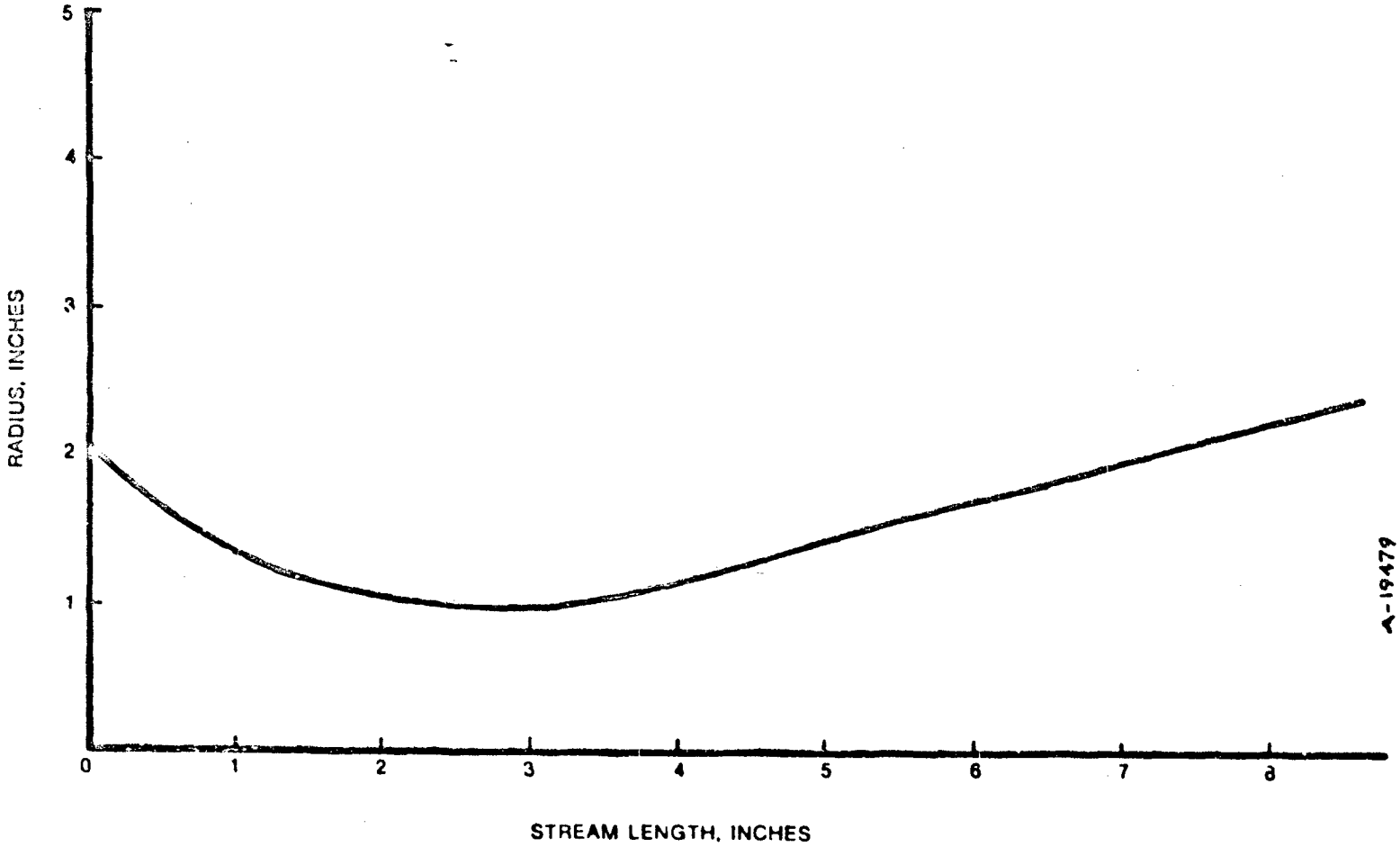


Figure 10. Nozzle radius vs. stream length for the C/CAN nozzle.

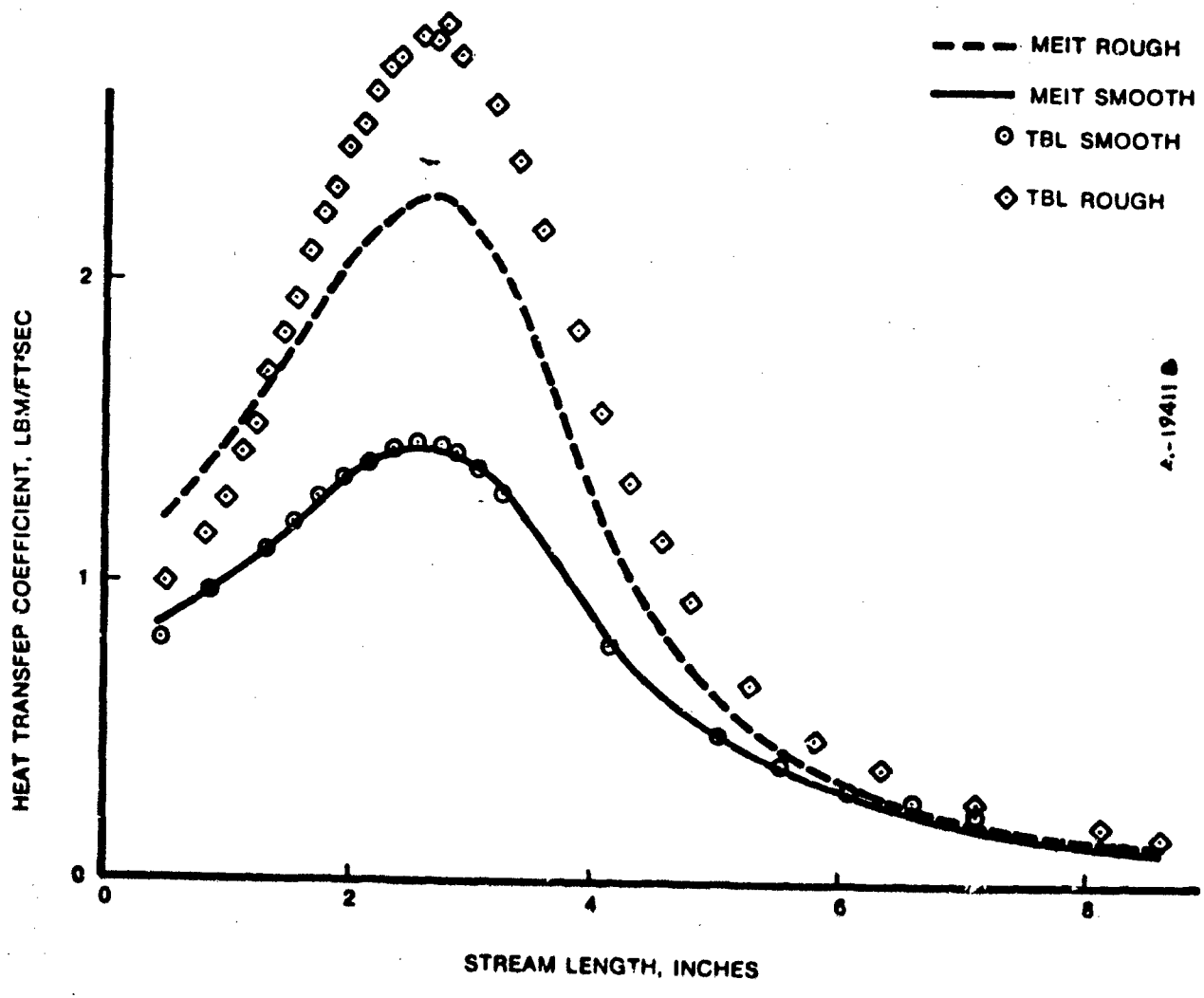


Figure 11. Heat transfer coefficients for the C/CAN nozzle.

- For nonblown , smooth wall and turbulent flow, both MEIT and ARGEIBL solve the same energy integral equation.
- Using the BLIMP solution as the criterion and a modifying factor of 0.75, the modified MEIT solution is better than the modified ARGEIBL solution.
- MEIT and TBL predict essentially the same heat transfer coefficient for smooth wall calculation.
- For rough wall calculation, MEIT predicts a lower heat transfer coefficient than TBL except in regions immediately downstream of the combustion chamber.
- MEIT is self-consistent in its roughness modelling.

The recommendations are:

- For both smooth and rough wall calculations, a factor of 0.75 should be used to modify the heat transfer coefficient generated by MEIT.
- Experiments or analyses should be conducted to deduce the heat transfer coefficient from actual motor firing data to check the validity of the surface roughness modelling in MEIT.
- A technique needs to be devised to evaluate nozzle material roughnesses for input into MEIT.
- When there is no firing data to modify the TBL heat transfer coefficient, the MEIT solution modofied by a 0.75 factor should be used for rough wall predictions.

SECTION 4

DESCRIPTIONS OF INPUT AND OUTPUT

This section provides detailed user oriented input instructions and a description of the output. The input instructions are presented in Section 4.1 and the output features are covered in Section 4.2.

4.1 INPUT INSTRUCTIONS

The program input consists of three card sets:

1. General program constants and transition information
2. Surface shape, boundary layer edge and wall conditions
3. Boundary layer gas properties

The description of these three card sets is given below.

Card Set 1 — Control Cards

This card set is made up of three cards which provide general program constants and transition information. The four blowing reduction parameters, $\lambda_{x,y}$, which are used to calculate the blowing influence coeffients (see Section 2.2), are also included in this card set

Card No.	Column	Format	Data	Unit
1	1	I1	NSM - No. of material, up to 3 allowed	-
	2	I1	IROUGH - Roughness height input flag 0 - Input as function of material (see below) 1 - Input as function of location (see Card Set 2)	-

Card No.	Column	Format	Data	Unit
	3-10	F8.5	CMH - Mass to heat transfer coefficient ratio, default value = 1.0	-
	11-20	F10.5	GAM2 - Isentropic exponent, default value = 1.2	-
2	1-10	F10.5	BTS - $\lambda_{f,t}$, default value = 0.5	-
	11-20	F10.5	BTH - $\lambda_{h,t}$, default value = 0.5	-
	21-30	F10.5	BLS - $\lambda_{f,l}$, default value = 0.35	-
	31-40	F10.5	BLH - $\lambda_{h,l}$, default value = 0.35	-
	41-50	F10.5	RUFL - Surface roughness height as function of material, input only if IROUGH = 0	mil
	Repeat card 2 for each material (number of cards equals NSM).			
2 + NSM	1-2	I2	NS - No. of body points (maximum 60)	-
	2-4	I2	IBRUPT - Abrupt transition flag 0 - laminar and transitional flow 1 - fully turbulent flow	-
	8-6	I2	NREYCR - Transition flag 0,7 - all turbulent 1 - all laminar 4 - transitional	-
	7-8	I2	IPRNT - Output print flag 1 - Detailed output at body point 2 - Detailed output at integration point	-
	9-12		Blank	
	13-22		DLTRAN - Axial location at which transition takes place, input only if NREYCR = 4	in

Card Set 2 — Body Point Data

This card set is made up of nine subsets and they provide the surface sharp, edge and wall condition information to the program. The nine subsets are:

- IMAT - Material index, default value = 1
- ZSP - Axial wall coordinates (in.)

- RSP - radial wall coordinates (in)
- PE - Edge pressure (atm)
- HE - Edge enthalpy (Btu/lbm)
- UE - Edge velocity (ft/sec)
- TSP - Wall temperature (°R)
- BPSP - Blowing parameter $\equiv {}^{(\rho v)_w}/_{\rho_e u_e C_M}$
- RUF2 - Surface roughness height (mil)
  RUF2 is input only if IROUGH = 1 (see Card Set 2).

The nine subsets are input in the above order. Each of these subsets has NS entries and each entry corresponds to a point on the heated surface of the body. The input format of all the subsets are F10.3 except IMAT which uses an input format of I10. The values of each subset are entered eight to a card. Since the solution for the first body point is based on stagnation conditions (see Section 2), it is recommended that the first entry in the velocity subset (UE) be zero.

Card Set 3 — Gas Property Tables

The gas property table provides the thermodynamic and transport properties of the boundary layer gas. This table is divided into subtables based on pressure. Within each pressure subtable, they are ordered either on temperature or enthalpy. If they are ordered on temperature, the same temperature array must be used for all other pressure subtables. The same is true for the enthalpy entries if the properties are input as functions of enthalpy and pressure.

Card No.	Column	Format	Data	Unit
1	1-3	I3	IPMAX - No. of pressure entries (maximum 21)	
	4-6	I3	IHMAX - No. of temperature or enthalpy entries (maximum 35)	
	7-12	I3	LTB - Temperature enthalpy flag 0- Properties input as functions of pressure and enthalpy 1- Properties input as functions of pressure and temperature	

Card No.	Column	Format	Data	Unit
2	1-10	F10.3	PT - Pressure	atm
3 to IHMAX + 2				
	1-12	E12.4	HT - Enthalpy	Btu/lbm
	13-24	E12.4	TEMT - Temperature	°R
	25-36	E12.4	EMT - Molecular weight	
	37-60		Blank	
	61-72	E12.4	ET - Viscosity	lbm/ft-sec
	73-80	F8.4	GT - Prandtl No.	

Cards 3 to IHMAX + 2 are repeated until the total number of pressures is equal to IPMAX. Note the pressure, enthalpy, and temperature entries must be input in ascending order.

4.2 OUTPUT DESCRIPTION

MEIT output can be divided into three categories. These are:

- Output of Input
- Output of Calculation Results
- Debug Output

The descriptions of each of these output are given below.

Output of Input

The program output begins with the output of the input. This output is made up of three parts:

- General program information
- Thermodynamic table
- General input information table

The general program information prints out the program constants contained in the first three input cards. These include mass to heat transfer coefficient ratio, isentropic exponent, the four blowing reduction parameters, and transition information. The FORTRAN names corresponding to

these variables are given in Section 4.1. The thermodynamic table tabulates the thermodynamic and transient properties of the boundary layer gas as functions of pressure. This table is self-explanatory. The general input information table gives the surface shape, boundary layer edge conditions and wall conditions. The variables printed in this table, their FORTRAN names and definitions are listed below:

- BODY PT NO (J)
  Index of the body points
- INTEG PT NO (I)
  Index of the integration point for which the computed parameters are printed
- MATL NO (MATL)
  Material index.
- STREAM LENGTH, inch (S)
  Stream length along the heated surface from the initial point to the integration points
- AXIAL LENGTH, inch (Z)
  Axial coordinate of the integration points with respect to the initial point
- RADIAL LENGTH, inch (R)
  Radial coordinate of the integration points with respect to the centerline
- BODY ANGLE, degrees (THETB)
  Angle which the tangent to the surface makes with respect to the centerline
- NORMALIZED ABLATION RATE (BPSP)
  Normalized ablation rate B' at the wall

$$B' \equiv \frac{(\rho v)_w}{\rho_e u_e C_M}$$

- WALL TEMP, °R (TW)
  Temperature of the wall

- SURFACE ROUGHNESS, mil (RUFMIL)
  Surface roughness height of the wall material
- PRESSURE, atm (PE)
  Edge pressure of the boundary layer
- ENTHALPY, Btu/lbm (HE)
  Edge enthalpy of the boundary layer
- VELOCITY, ft/sec (UE)
  Edge velocity of the boundary layer

Output of Calculation Results

The results of the code calculations are printed out in three tables. These three tables are:

1. Viscous Flow - Edge Properties
2. Viscous Flow - Wall and B. L. Recovery Properties
3. Viscous Flow - Boundary Layer Solution

The variables printed in each table, their FORTRAN names and definitions are listed below.

1. Viscous Flow - Edge Properties Table

- BODY PT NO (J)
  Index of the body points
- INTEG PT NO (I)
  Index of the integration point for which the computed parameters are printed
- STREAM LENGTH, inch (S)
  Stream length along the heated surface from the initial point to the integration points
- VELOCITY, ft/sec (UE)
  Velocity at the edge of the boundary layer
- MACH NO (HCAM)
  Mach number at the edge of the boundary layer

- ENTHALPY, Btu/lbm (HE)
  Ehthalpy at the edge of the boundary layer
- TEMPERATURE, °R (TE)
  Temperature at the edge of the boundary layer
- DENSITY, lbm/ft^3 (ROE)
  Density at the edge of the boundary layer
- VISCOSITY, lbm/ft-sec (VISE)
  Viscosity at the edge of the boundary layer
- UNIT RE NO, 1/ft (URE)
  Unit Reynolds number at the edge of the boundary layer

Note that the Mach number given in this table is valid only if there are no condensed species in the freestream.

2. Viscous Flow - Wall and B.L. Recovery Properties Table

- BODY PT NO (J)
  Index of the body points
- INTEG PT NO (L)
  Index of the integration point for which the computer parameters are printed
- STREAM LENGTH, inch (S)
  Stream length along the heated surface from the initial point to the integration points
- WALL TEMPERATURE, °R (TW)
  Temperature at the wall
- WALL ENTHALPY, Btu/lbm (HW)
  Enthalpy of gas at wall temperature and pressure
- WALL DENSITY, lbm/ft^3 (ROW)
  Density of gas at wall temperature and pressure
- WALL VISCOSITY, lbm/ft-sec (VISW)
  Viscosity of gas at wall temperature and pressure

- RECOVERY ENTHALPY, Btu/lbm (HR)
  Recovery enthalpy defined by $h_r \equiv h_e + F\,(h_t - h_e)$

- RECOVERY FACTOR (RECOV)
  Recovery Factor defined by $F = Pr^n$, $n = \begin{cases} 1/2 \text{ for laminar flow} \\ 1/3 \text{ for turbulent flow} \end{cases}$

- SENSBL CONV HEAT FLUX, Btu/ft^2 sec
  Sensible convective heat flux defined by $\dot{q}_w = \rho_e u_e C_H\,(h_r - h_w)$

- CF/2
  Function coefficient $C_f/2 \equiv \tau_w/(\rho_e u_e^2)$

3. Viscous Flow — Boundary Layer Solution Table

- BODY PT NO (J)
  Index of the body points

- INTEG PT NO (I)
  Index of the integration point for which the computed parameters are printed

- STREAM LENGTH, inch (S)
  Stream length along the heated surface from the stagnation point to the integration points

- MOMENTUM THICKNESS, mil (THE)
  Momentum thickness θ of the boundary layer

- ENERGY THICKNESS, mil (PHI)
  Energy thickness ϕ of the boundary layer

- SHAPE FACTOR (HSF)
  Boundary layer shape factor, $H \equiv \delta^*/\theta$

  where $\delta^* \equiv \int_0^\delta \left(1 - \frac{\rho u}{\rho_e u_e}\right) dy$ is the boundary layer displacement thickness.

- MOM THICK RE NO (RETH)
  Reynolds number based on the momentum thickness, $Re_\theta = \frac{\rho_e u_e \theta}{\mu_e}$

- ENERGY THICK RE NO (REPH)
  Reynolds number based on the energy thickness, $Re_\phi = \frac{\rho_e u_e \phi}{\mu_e}$

- HEAT TRANS COEFFICIENT, lbm/ft^{2}sec (RUCH)
  Heat transfer coefficient, $\rho_e u_e C_h \equiv \dot{q}_w/(h_r - h_w)$
  where C_h is the Stanton number and $\dot{q}_w$ is the wall heat flux

- REYNOLDS ANAL FAC (RAF)
  Reynolds analogy factor $C_h/(C_f/2)$

- INTERMITTENCY (ADML)
  Boundary layer intermittency factor f, where $0 \leq f \leq 1$ for flow ranging from fully laminar to fully turbulent regime

- HEAT TRANS AUGMENT (RUFSMT)
  Heat transfer augmentation due to surface roughness, this quantity is equivalent to the roughness influence coefficient

As mentioned in Section 2, the solutions for the first three integration points are only for start up purpose. These solutions should be ignored in the output.

Debug Output

There are four error messages output by MEIT. The error messages and their meanings are given below.

- ******** Wrong Pressure Input Ordering
  The pressure entries in the boundary layer gas properties table are not in ascending order.

- ********* Wrong Temperature/Enthalpy Input Ordering
  The temperature or enthalpy entries in the boundary layer gas properties table are not in ascending order.

- ********* Input Temperature/Enthalpy Error
  The corresponding temperature or enthalpy entries in the boundary layer gas properties table are not the same for different pressure entries.

— Computation of MEIT equations did not converge at Point I. The MEIT calculations at Integration Point I did not converge after 30 tries.

There are also other debug output built in MEIT. However, since these output are only useful to the very sophisticated users who are intimately familiar with the program logic, they are not described here.

SECTION 5

SAMPLE PROBLEMS

Presented in this section are two sample problems which were run on a Univac 1108 Digital Computer. For each sample problem, the following is presented:

- A brief description of the nature of the problem and solution.
- A listing of the input data deck.
- A listing of the output.

Sample Problem 1

This is a smooth wall calculation for the Aerojet MX upper stage nozzle with a PEG/FEFO propellant. The details of this system were described in Section 3. A total of 21 body points were input. The wall temperature was assumed to be 5500°R. A IPRNT = 1 option was used which printed out only the body point solutions.

INPUT LISTING OF SAMPLE PROBLEM NO. 1

```
1  .7839  1.2784

21 1 7 1


0.          1.66363   2.81637   2.51659   3.17918   3.85984   4.23981   4.61979
4.97986   5.36262   5.86134   5.72631   5.97234   6.21841   6.62142   7.00631
7.91796   13.88933  28.45066  30.76366  44.16933
   6.48000   4.95996   4.44800   4.02000   3.65004   3.39000   3.30000   3.21996
   3.18996   3.17004   3.14604   3.14904   3.16404   3.18996   3.27000   3.38004
   3.780006.63996   9.87      18.5      17.4996
 100.00000  97.23560  94.37240  90.00830  83.27080  74.44780  69.47120  63.15230
  59.56400  56.85890  47.74930  44.58640  40.08090  35.78410  29.09960  22.65110
  11.333202.6765    1.2658    .6355     .3356
1692.200001658,780001657,890001605,280001552,100011477,100011431,660001370,14999
1331.200001304,800001197,360001156,240011094,149991028,10001 915,30000 783,88000
 484.29000-31.62    -296.84   -463.52   -594.98
    .000001295,100011648,800002086,000002648,299993281,500003611,399994015,20001
4251.099984406,599984977,099985179,799993471,599985765,799996286,299996743,20001
7865,700019423,2    9976.5    10388.    10700.
5500.     5500.     5500.     5500.     5500.     5500.     5500.     5500.
5500.     5500.     5500.     5500.     5500.     5500.     5500.     5500.
5500.     5500.     5500.     5500.     5500.


  6 16
 .8
  -.63000+03   .18017+04   .19427+02   .62802+00   -.13643+00   .22338-04   .4589
  -.54000+03   .19042+04   .19335+02   .43641+00   -.10187-01   .23792-04   .4584
  -.36000+03   .24059+04   .19327+02   .42661+00   -.12184-03   .27012-04   .4606
  -.18000+03   .28248+04   .19327+02   .43350+00   -.36275-03   .30026-04   .4613
  -.90000+02   .30312+04   .19326+02   .43913+00   -.10726-02   .31453-04   .4613
   .90000+02   .34326+04   .19319+02   .46108+00   -.62624-02   .34138-04   .4609
   .18000+03   .36239+04   .19309+02   .48155+00   -.12644-01   .35378-04   .4604
   .36000+03   .39753+04   .19267+02   .55137+00   -.38546-01   .37595-04   .4591
   .54000+03   .42743+04   .19185+02   .66268+00   -.84625-01   .39418-04   .4570
   .72000+03   .45203+04   .19063+02   .80608+00   -.14086+00   .40876-04   .4543
   .90000+03   .47247+04   .18908+02   .96674+00   -.22509+00   .42047-04   .4511
   .10800+04   .48955+04   .18730+02   .11368+01   -.30782+00   .43005-04   .4476
   .12600+04   .50457+04   .18537+02   .13094+01   -.39296+00   .43807-04   .4440
   .14400+04   .51729+04   .18335+02   .14800+01   -.47780+00   .44492-04   .4402
   .16200+04   .52802+04   .18127+02   .16454+01   -.56029+00   .45088-04   .4364
   .17100+04   .53418+04   .18021+02   .17254+01   -.60018+00   .45360-04   .4345
1.
  -.63000+03   .18690+04   .19633+02   .90369+00   -.33382+00   .22910-04   .4648
  -.54000+03   .20020+04   .19389+02   .52758+00   -.77674-01   .23980-04   .4620
  -.36000+03   .24062+04   .19328+02   .42752+00   -.99089-03   .27014-04   .4606
  -.18000+03   .28251+04   .19327+02   .43297+00   -.24980-03   .30027-04   .4613
  -.90000+02   .30319+04   .19326+02   .43756+00   -.61230-03   .31458-04   .4613
   .90000+02   .34370+04   .19322+02   .45297+00   -.35002-02   .34168-04   .4610
   .18000+03   .36330+04   .19317+02   .46627+00   -.71631-02   .35439-04   .4606
   .36000+03   .40053+04   .19291+02   .51148+00   -.22685-01   .37774-04   .4595
```

.84000+03	.43329+04	.19236+02	.58760+00	-.53917-01	.39785-04	.4578
.72000+03	.46150+04	.19144+02	.69175+00	-.10139+00	.41457-04	.4555
.90000+03	.48558+04	.19019+02	.81593+00	-.16219+00	.42838-04	.4527
.10800+04	.50596+04	.18867+02	.95318+00	-.23180+00	.43977-04	.4496
.12600+04	.52356+04	.18695+02	.10964+01	-.30623+00	.44937-04	.4463
.14400+04	.53898+04	.18509+02	.12409+01	-.38243+00	.45757-04	.4429
.16200+04	.55271+04	.18315+02	.13833+01	-.45818+00	.46471-04	.4393
.17100+04	.55906+04	.18216+02	.14529+01	-.49534+00	.46795-04	.4376
88.						
-.63000+03	.21718+04	.20655+02	.12487+01	-.70183+00	.25462-04	.4955
-.54000+03	.22547+04	.20203+02	.10486+01	-.54271+00	.26002-04	.4841
-.36000+03	.24759+04	.19551+02	.62632+00	-.18728+00	.27561-04	.4672
-.18000+03	.28320+04	.19351+02	.44992+00	-.19093-01	.30080-04	.4621
-.90000+02	.30348+04	.19336+02	.44083+00	-.58883-02	.31440-04	.4616
.90000+02	.34419+04	.19329+02	.44545+00	-.16054-02	.34201-04	.4611
.18000+03	.36428+04	.19327+02	.45083+00	-.19408-02	.35503-04	.4608
.36000+03	.40350+04	.19321+02	.46657+00	-.31996-02	.37982-04	.4600
.54000+03	.44123+04	.19306+02	.49156+00	-.15232-01	.40278-04	.4589
.72000+03	.47668+04	.19276+02	.52579+00	-.28214-01	.42376-04	.4575
.90000+03	.50954+04	.19226+02	.57268+00	-.51711-01	.44267-04	.4558
.10800+04	.53949+04	.19153+02	.63227+00	-.83068-01	.45947-04	.4538
.12600+04	.56683+04	.19058+02	.70120+00	-.12357+00	.47428-04	.4516
.14400+04	.59089+04	.18941+02	.77845+00	-.16911+00	.48731-04	.4492
.16200+04	.61289+04	.18808+02	.85909+00	-.21865+00	.49883-04	.4466
.17100+04	.62313+04	.18736+02	.90018+00	-.24439+00	.50410-04	.4452
80.						
-.63000+03	.22609+04	.20957+02	.12488+01	-.73045+00	.26150-04	.5049
-.54000+03	.23383+04	.20491+02	.10862+01	-.68399+00	.26673-04	.4929
-.36000+03	.25381+04	.19754+02	.78384+00	-.29757+00	.28046-04	.4733
-.18000+03	.28477+04	.19483+02	.48758+00	-.59957-01	.30198-04	.4636
-.90000+02	.30405+04	.19336+02	.9337+00	-.20628-01	.31522-04	.4623
.90000+02	.34482+04	.19334+02	.44642+00	-.85729-02	.34218-04	.4613
.18000+03	.36490+04	.19331+02	.45031+00	-.25150-02	.35512-04	.4609
.36000+03	.40386+04	.19325+02	.46313+00	-.40658-02	.38000-04	.4601
.54000+03	.44196+04	.19314+02	.48316+00	-.96855-02	.40324-04	.4591
.72000+03	.47828+04	.19292+02	.50933+00	-.20713-01	.42478-04	.4577
.90000+03	.51248+04	.19253+02	.54561+00	-.38634-01	.44442-04	.4562
.10800+04	.54417+04	.19195+02	.59281+00	-.64845-01	.46220-04	.4544
.12600+04	.57328+04	.19116+02	.64936+00	-.96809-01	.47810-04	.4525
.14400+04	.59967+04	.19017+02	.71295+00	-.13487+00	.49227-04	.4503
.16200+04	.62379+04	.18901+02	.78122+00	-.17768+00	.50491-04	.4479
.17100+04	.63506+04	.18837+02	.81644+00	-.20029+00	.51073-04	.4467
70.						
-.63000+03	.23131+04	.21181+02	.12249+01	-.73008+00	.26972-04	.5109
-.54000+03	.23906+04	.20678+02	.10947+01	-.63809+00	.27090-04	.4986
-.36000+03	.25831+04	.19904+02	.78710+00	-.35735+00	.28396-04	.4778
-.18000+03	.28664+04	.19466+02	.52672+00	-.10822+00	.30339-04	.4655
-.90000+02	.30486+04	.19385+02	.47065+00	-.40859-01	.31582-04	.4631
.90000+02	.34498+04	.19341+02	.44863+00	-.69379-02	.34222-04	.4615
.18000+03	.36450+04	.19335+02	.45082+00	-.38519-02	.35519-04	.4610
.36000+03	.40298+04	.19328+02	.46177+00	-.38558-02	.38009-04	.4602
.54000+03	.44031+04	.19319+02	.47942+00	-.81884-02	.40345-04	.4592
.72000+03	.47583+04	.19300+02	.50178+00	-.17285-01	.42516-04	.4579
.90000+03	.51389+04	.19267+02	.53285+00	-.32421-01	.44525-04	.4564
.10800+04	.54649+04	.19217+02	.57373+00	-.54315-01	.46355-04	.4548
.12600+04	.57641+04	.19147+02	.62534+00	-.82829-01	.48005-04	.4529
.14400+04	.60427+04	.19058+02	.67990+00	-.11712+00	.49487-04	.4509

.16200+04	.62963+04	.18952+02	.74181+00	-.15598+00	.50817-04	.4487
.17100+04	.64182+04	.18893+02	.77328+00	-.17671+00	.51438-04	.4475
180.						
-.63000+03	.23513+04	.21295+02	.12184+01	-.74121+00	.26879-04	.5154
-.54000+03	.24298+04	.20818+02	.10954+01	-.64426+00	.27397-04	.5030
-.36000+03	.26180+04	.20023+02	.81875+00	-.39572+00	.28664-04	.4814
-.18000+03	.28853+04	.19529+02	.56084+00	-.14160+00	.30481-04	.4674
-.90000+02	.30583+04	.19418+02	.48972+00	-.63285-01	.31654-04	.4641
.90000+02	.34468+04	.19349+02	.45175+00	-.11190-01	.34237-04	.4617
.18000+03	.36462+04	.19340+02	.45190+00	-.57581-02	.35527-04	.4612
.36000+03	.40418+04	.19331+02	.46114+00	-.40264-02	.38016-04	.4603
.54000+03	.44252+04	.19322+02	.47722+00	-.73947-02	.40359-04	.4593
.72000+03	.47949+04	.19305+02	.49721+00	-.15242-01	.42547-04	.4580
.90000+03	.51477+04	.19276+02	.52499+00	-.28595-01	.44578-04	.4565
.10800+04	.54795+04	.19231+02	.56180+00	-.48193-01	.46448-04	.4550
.12600+04	.57881+04	.19167+02	.60688+00	-.74058-01	.48131-04	.4532
.14400+04	.60729+04	.19086+02	.65871+00	-.10555+00	.49657-04	.4513
.16200+04	.63352+04	.18987+02	.71543+00	-.14164+00	.51033-04	.4492
.17100+04	.64584+04	.18932+02	.74509+00	-.16103+00	.51669-04	.4481

SAMPLE PROBLEM 1 OUTPUT

```
                MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

NUMBER OF MATERIALS =   1
CR/CH =      .78398
ISENTROPIC EXPONENT =    1.27648


MATL            BTS             BTH             BLS             BLH
  1             .35000          .35000          .50000          .50000


NS = 21
IBRUPT =  1
NREYCR =  7
IPRNT =  1
DLTRAN =      .00000  INCHES


ABRUPT TRANSITION

FLOW IS TURBULENT
```

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

THERMODYNAMIC TABLE

PRESSURE = .300ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	1801.7000	19.4270	.000022	.4589
-540.0000	1984.2000	19.3350	.000024	.4584
-360.0000	2405.9000	19.3270	.000027	.4606
-180.0000	2824.8000	19.3270	.000030	.4613
-90.0000	3031.2000	19.3260	.000031	.4613
90.0000	3432.6000	19.3190	.000034	.4609
180.0000	3623.9000	19.3090	.000035	.4604
360.0000	3975.5000	19.2670	.000038	.4591
540.0000	4274.3000	19.1850	.000039	.4570
720.0000	4520.8000	19.0650	.000041	.4543
900.0000	4724.7000	18.9080	.000042	.4511
1080.0000	4896.3000	18.7300	.000043	.4476
1260.0000	5043.7000	18.5370	.000044	.4440
1440.0000	5172.9000	18.3350	.000044	.4402
1620.0000	5288.2000	18.1270	.000045	.4364
1710.0000	5341.6000	18.0210	.000045	.4345

PRESSURE = 1.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	1869.0000	19.6330	.000023	.4648
-540.0000	2002.0000	19.5890	.000024	.4600
-360.0000	2406.2000	19.3260	.000027	.4606
-180.0000	2825.1000	19.3270	.000030	.4613
-90.0000	3031.9000	19.3260	.000031	.4613
90.0000	3437.0000	19.3220	.000034	.4610
180.0000	3633.0000	19.3170	.000035	.4606
360.0000	4003.3000	19.2910	.000038	.4595
540.0000	4332.9000	19.2360	.000040	.4578
720.0000	4615.8000	19.1440	.000041	.4555
900.0000	4855.9000	19.0190	.000043	.4527
1080.0000	5059.6000	18.8670	.000044	.4496
1260.0000	5235.6000	18.6950	.000045	.4463
1440.0000	5389.8000	18.5090	.000046	.4429
1620.0000	5527.1000	18.3150	.000046	.4393
1710.0000	5[illegible]0.4000	18.2160	.000047	.4376

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 25.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	2176.8000	20.6530	.000025	.4955
-540.0000	2294.7000	20.2030	.000026	.4841
-360.0000	2475.9000	19.5510	.000028	.4672
-180.0000	2832.0000	19.3510	.000030	.4621
-90.0000	3084.8000	19.3360	.000031	.4616
90.0000	3441.9000	19.3290	.000034	.4611
180.0000	3642.8000	19.3270	.000036	.4603
360.0000	4035.8000	19.3210	.000038	.4600
540.0000	4412.3000	19.3060	.000040	.4589
720.0000	4766.8000	19.2760	.000042	.4575
900.0000	5095.4000	19.2260	.000044	.4558
1080.0000	5394.9000	19.1530	.000046	.4538
1260.0000	5665.3000	19.0580	.000047	.4516
1440.0000	5908.9000	18.9410	.000049	.4492
1620.0000	6128.9000	18.8080	.000050	.4466
1710.0000	6231.3000	18.7360	.000050	.4452

PRESSURE = 50.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	2260.9000	20.9570	.000026	.5049
-540.0000	2383.3000	20.4910	.000027	.4929
-360.0000	2538.3000	19.7540	.000028	.4783
-180.0000	2847.7000	19.4030	.000030	.4686
-90.0000	3040.5000	19.3560	.000032	.4625
90.0000	3443.2000	19.3340	.000034	.4613
180.0000	3644.0000	19.3310	.000036	.4609
360.0000	4038.6000	19.3250	.000038	.4601
540.0000	4419.6000	19.3140	.000040	.4591
720.0000	4782.8000	19.2920	.000042	.4577
900.0000	5124.8000	19.2550	.000044	.4562
1080.0000	5441.7000	19.1950	.000046	.4544
1260.0000	5732.0000	19.1160	.000048	.4525
1440.0000	5996.7000	19.0170	.000049	.4503
1620.0000	6237.9000	18.9010	.000050	.4479
1710.0000	6350.6000	18.8370	.000051	.4467

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 75.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	2813.1000	21.1510	.000027	.5109
-540.0000	2890.6000	20.6780	.000027	.4986
-360.0000	2583.1000	19.9040	.000028	.4778
-180.0000	2866.4000	19.4660	.000030	.4655
-90.0000	3048.6000	19.3850	.000032	.4631
90.0000	3444.8000	19.3410	.000034	.4615
180.0000	3645.0000	19.3350	.000036	.4610
360.0000	4040.0000	19.3280	.000038	.4602
540.0000	4423.1000	19.3190	.000040	.4592
720.0000	4790.3000	19.3000	.000043	.4579
900.0000	5138.9000	19.2670	.000045	.4564
1080.0000	5464.9000	19.2170	.000046	.4548
1260.0000	5766.1000	19.1470	.000048	.4529
1440.0000	6042.7000	19.0580	.000049	.4509
1620.0000	6296.3000	18.9520	.000051	.4487
1710.0000	6415.2000	18.8930	.000051	.4475

PRESSURE = 100.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-630.0000	2851.8000	21.2950	.000027	.5154
-540.0000	2929.3000	20.8180	.000027	.5030
-360.0000	2618.0000	20.0230	.000029	.4814
-180.0000	2885.3000	19.5290	.000030	.4674
-90.0000	3058.3000	19.4180	.000032	.4641
90.0000	3446.8000	19.3490	.000034	.4617
180.0000	3646.2000	19.3400	.000036	.4612
360.0000	4041.0000	19.3310	.000038	.4603
540.0000	4425.2000	19.3220	.000040	.4593
720.0000	4794.9000	19.3050	.000043	.4580
900.0000	5147.7000	19.2760	.000045	.4565
1080.0000	5479.5000	19.2310	.000046	.4550
1260.0000	5788.1000	19.1670	.000048	.4532
1440.0000	6072.9000	19.0860	.000050	.4513
1620.0000	6335.2000	18.9870	.000051	.4492
1710.0000	6458.4000	18.9320	.000052	.4481

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

GENERAL INPUT INFORMATION

****

BODY PT NO (J)	INTEG PT NO (I)	RATL NO (RATL)	STREAM LENGTH INCH (S)	AXIAL LENGTH INCH (Z)	RADIAL LENGTH INCH (R)	BODY ANGLE DEG (THETB)	NORMALIZED ABLATION RATE (BPSP)	WALL TEMP DEG R (TW)	SURFACE ROUGHNESS MIL (RUFMIL)	---EDGE CONDITION--- PRESSURE ATM (PE)	ENTHALPY BTU/LBM (HE)	VELOCITY FT/SEC (UE)
1	1	1	.00	.000	6.480	-42.418	.000	5500.00	.000	100.00	1692.20	.00
2	7	1	2.25	1.664	4.940	-45.334	.000	5500.00	.000	97.24	1658.70	1295.10
3	9	1	2.88	2.016	4.440	-47.778	.000	5500.00	.000	94.37	1637.89	1648.80
4	11	1	3.53	2.517	4.020	-34.190	.000	5500.00	.000	90.01	1605.28	2086.00
5	13	1	4.29	3.179	3.650	-25.127	.000	5500.00	.000	83.27	1552.10	2648.30
6	15	1	5.02	3.860	3.390	-18.264	.000	5500.00	.000	74.45	1477.10	3281.50
7	17	1	5.41	4.240	3.300	-12.612	.000	5500.00	.000	69.47	1431.66	3611.40
8	19	1	5.80	4.620	3.220	-8.487	.000	5500.00	.000	63.15	1370.15	4015.20
9	21	1	6.16	4.980	3.190	-5.845	.000	5500.00	.000	59.36	1331.20	4251.10
10	23	1	6.55	5.365	3.170	-4.319	.000	5500.00	.000	56.86	1304.30	4406.60
11	25	1	6.75	5.561	3.146	-3.305	.000	5500.00	.000	47.75	1197.36	4977.10
12	27	1	6.91	5.726	3.149	2.508	.000	5500.00	.000	44.59	1156.24	5179.60
13	29	1	7.16	5.972	3.164	4.753	.000	5500.00	.000	40.08	1094.15	5471.60
14	31	1	7.40	6.218	3.190	9.272	.000	5500.00	.000	35.70	1028.10	5765.80
15	33	1	7.82	6.621	3.270	13.563	.000	5500.00	.000	29.10	915.30	6236.30
16	35	1	8.22	7.006	3.330	21.472	.000	5500.00	.000	22.65	783.88	6743.20
17	38	1	9.21	7.918	3.780	28.187	.000	5500.00	.000	11.33	456.29	7865.70
18	53	1	13.12	13.089	6.640	25.916	.000	5500.00	.000	2.68	-81.62	9423.20
19	74	1	23.16	20.451	9.870	21.215	.000	5500.00	.000	1.27	-296.84	9978.50
20	102	1	34.09	30.764	13.500	17.835	.000	5500.00	.000	.64	-463.52	10308.00
21	136	1	48.03	44.164	17.500	16.618	.000	5500.00	.000	.34	-594.93	10700.00

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - EDGE PROPERTIES

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	VELOCITY FT/SEC (UE)	MACH NO (HCAM)	ENTHALPY BTU/LBM (HE)	TEMPERATURE DEG R (TE)	DENSITY LBM/FT3 (ROE)	VISCOSITY LBM/FT-SEC (VISE)	UNIT RE NO 1/FT (URE)
1	1	.0000	.0	.0000	1692.2	6434.0	4.031-01	5.154-05	0.000
2	7	2.2535	1295.1	.2799	1656.7	6384.2	3.954-01	5.128-05	9.985+06
3	9	2.8818	1648.8	.3574	1637.9	6351.7	3.859-01	5.112-05	1.245+07
4	11	3.8850	2084.0	.4542	1605.8	6299.8	3.714-01	5.084-05	1.524+07
5	13	4.2934	2348.3	.5809	1552.1	6213.6	3.487-01	5.039-05	1.833+07
6	15	5.0225	3281.8	.7274	1477.1	6094.2	3.184-01	4.976-05	2.100+07
7	17	5.4130	3611.4	.8058	1431.7	6021.3	3.010-01	4.937-05	2.202+07
8	19	5.8013	4015.2	.9042	1370.1	5917.8	2.787-01	4.881-05	2.293+07
9	21	6.1626	4251.1	.9630	1331.2	5853.1	2.651-01	4.846-05	2.326+07
10	23	6.5459	4406.6	1.0022	1304.3	5808.9	2.560-01	4.823-05	2.339+07
11	25	6.7960	4977.4	1.1513	1197.4	5627.0	2.224-01	4.723-05	2.343+07
12	27	6.9110	5179.8	1.2063	1156.2	5555.5	2.105-01	4.684-05	2.326+07
13	29	7.1875	5471.6	1.2873	1094.1	5449.1	1.931-01	4.626-05	2.284+07
14	31	7.4050	5765.8	1.3723	1028.1	5330.0	1.760-01	4.559-05	2.227+07
15	33	7.8158	6236.3	1.5146	918.3	5127.6	1.494-01	4.445-05	2.096+07
16	35	8.2162	6743.2	1.6803	783.9	4877.8	1.224-01	4.301-05	1.919+07
17	38	9.2117	7865.7	2.1090	456.3	4223.1	7.092-02	3.912-05	1.426+07
18	53	15.1212	9423.2	2.9745	-81.6	3051.7	2.321-02	3.159-05	6.924+06
19	74	23.1606	9976.5	3.4421	-296.8	2556.7	1.311-02	2.810-05	4.656+06
20	102	34.0932	10388.0	3.8909	-463.5	2169.8	7.760-03	2.521-05	3.197+06
21	138	48.0780	10700.0	4.3148	-595.0	1877.2	4.750-03	2.294-05	2.218+06

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - WALL AND B. L. RECOVERY PROPERTIES

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	WALL TEMPERATURE DEG R (TW)	WALL ENTHALPY BTU/LBM (HW)	WALL DENSITY LBM/FT3 (ROW)	WALL VISCOSITY LBM/FT-SEC (VISW)	RECOVERY ENTHALPY BTU/LBM (HR)	RECOVERY FACTOR (RECOV)	SENSBL CONV HEAT FLUX BTU/FT2-SEC	CF/2
1	1	.0000	5500.0	1092.0	4.787-01	4.655-05	1692.2	.6721	2.864+02	1.000+30
2	7	2.2535	5500.0	1092.8	4.654-01	4.655-05	1684.4	.7673	8.660+02	2.264-03
3	9	2.8818	5500.0	1093.8	4.516-01	4.655-05	1679.5	.7673	9.407+02	2.056-03
4	11	3.5850	5500.0	1095.3	4.307-01	4.655-05	1672.0	.7673	1.030+03	1.922-03
5	13	4.2938	5500.0	1097.7	3.983-01	4.655-05	1659.6	.7673	1.104+03	1.797-03
6	15	5.0225	5500.0	1101.3	3.560-01	4.655-05	1642.1	.7673	1.128+03	1.703-03
7	17	5.4130	5500.0	1103.8	3.321-01	4.655-05	1631.6	.7673	1.112+03	1.659-03
8	19	5.8013	5500.0	1107.4	3.018-01	4.655-05	1617.3	.7673	1.073+03	1.616-03
9	21	6.1626	5500.0	1109.7	2.836-01	4.654-05	1608.3	.7673	1.033+03	1.560-03
10	23	6.5459	5500.0	1111.3	2.716-01	4.654-05	1602.0	.7673	1.006+03	1.564-03
11	25	6.7460	5500.0	1118.4	2.279-01	4.654-05	1577.2	.7673	8.963+02	1.574-03
12	27	6.9110	5500.0	1121.7	2.128-01	4.654-05	1567.7	.7673	8.456+02	1.546-03
13	29	7.1575	5500.0	1126.4	1.912-01	4.653-05	1553.3	.7673	7.705+02	1.525-03
14	31	7.4050	5500.0	1132.0	1.702-01	4.653-05	1538.0	.7673	6.905+02	1.503-03
15	33	7.6158	5500.0	1142.1	1.386-01	4.653-05	1512.0	.7673	5.597+02	1.471-03
16	35	8.2162	5500.0	1157.6	1.077-01	4.652-05	1481.6	.7673	4.182+02	1.437-03
17	38	9.2117	5500.0	1216.5	8.360-02	4.649-05	1406.0	.7673	1.479+02	1.382-03
18	53	15.1212	5500.0	1391.9	1.245-02	4.641-05	1281.8	.7673	-2.629+01	1.081-03
19	74	23.1600	5500.0	1530.6	5.813-03	4.635-05	1231.7	.7673	-3.575+01	8.782-04
20	102	34.0932	5500.0	1714.8	2.869-03	4.627-05	1191.9	.7673	-3.727+01	7.600-04
21	136	48.0760	5500.0	1953.9	1.485-03	4.618-05	1159.4	.7673	-3.687+01	6.692-04

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - BOUNDARY LAYER SOLUTION

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	MOMENTUM THICKNESS MIL (THE)	ENERGY THICKNESS MIL (PHI)	SHAPE FACTOR (HSF)	MOM THICK RE NO (RETH)	ENERGY THICK RE NO (REPH)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (HUCH)	REYNOLDS ANAL FAC (RAF)	INTER-MITTENCY (ADML)	HEAT TRANS AUGMENT (RUFSMT)
1	1	.0000	.422	1.026	1.975	0.000	0.000	4.771-01	.9780	.00	1.000
2	7	2.2535	1.653	3.582	1.096	1.376+03	2.981+03	1.464+00	1.2628	1.00	1.000
3	9	2.8818	1.94	4.801	1.081	2.012+03	4.981+03	1.606+00	1.2273	1.00	1.000
4	11	3.5350	2.085	5.832	1.083	2.647+03	7.405+03	1.786+00	1.2002	1.00	1.000
5	13	4.2936	2.261	6.963	1.100	3.453+03	1.063+04	1.965+00	1.1839	1.00	1.000
6	15	5.0225	2.403	8.037	1.183	4.208+03	1.406+04	2.085+00	1.1722	1.00	1.000
7	17	5.4130	2.523	8.664	1.155	4.680+03	1.590+04	2.108+00	1.1687	1.00	1.000
8	19	5.8013	2.594	9.334	1.190	4.957+03	1.784+04	2.104+00	1.1635	1.00	1.000
9	21	6.1626	2.836	9.976	1.211	5.497+03	1.933+04	2.072+00	1.1785	1.00	1.000
10	23	6.5459	3.068	10.654	1.225	5.981+03	2.077+04	2.051+00	1.1627	1.00	1.000
11	25	6.7460	2.741	11.379	1.299	5.353+03	2.222+04	1.953+00	1.1210	1.00	1.000
12	27	6.9110	2.769	11.840	1.328	5.370+03	2.296+04	1.896+00	1.1246	1.00	1.000
13	29	7.1075	2.863	12.591	1.372	5.450+03	2.397+04	1.805+00	1.1199	1.00	1.000
14	31	7.4050	2.971	13.446	1.424	5.512+03	2.495+04	1.701+00	1.1146	1.00	1.000
15	33	7.8158	3.173	15.049	1.518	5.543+03	2.629+04	1.514+00	1.1046	1.00	1.000
16	35	8.2162	3.398	17.344	1.645	5.480+03	2.774+04	1.291+00	1.0881	1.00	1.000
17	36	9.2117	4.247	26.760	2.052	5.046+03	3.180+04	7.608-01	1.0512	1.00	1.000
18	53	15.1212	9.441	63.956	3.204	5.447+03	3.690+04	2.388-01	1.0590	1.00	1.000
19	74	23.1600	15.329	123.554	4.005	5.947+03	4.794+04	1.196-01	1.0409	1.00	1.000
20	102	34.0932	23.402	96.456	4.867	6.235+03	2.570+04	7.129-02	1.1637	1.00	1.000
21	138	48.6780	33.805	80.479	5.799	6.241+03	9.320+03	4.761-02	1.3996	1.00	1.000

Sample Problem 2

A rough wall calculation for the C/CAN nozzle with a HT 90/18 propellant was performed. The details of this system were given in Section 3. Fifty-six body points were input. The surface roughness and the wall temperature used in this calculation are 2 mil and 4939°R respectively. Solutions at all the integration points were printed (IPRNT=2).

INPUT LISTING OF SAMPLE PROBLEM 2

```
1  .76168 1.1649

56 1 7 2                                                    2.

  -2.2500   -2.2000   -2.1500   -2.1000   -2.0500   -2.0000   -1.9500   -1.9000
  -1.8500   -1.8000   -1.7000   -1.6000   -1.5000   -1.4000   -1.3000   -1.2000
  -1.1000   -1.0000    -.9000    -.8000    -.7000    -.6000    -.5000    -.3000
   -.2000    -.1000     .0000     .1000     .2000     .3000     .4000     .5000
    .6000     .7000     .8000     .9000    1.0000    1.2000    1.4500    1.7000
   1.9500    2.2000    2.4500    2.7000    2.9500    3.2000    3.4500    3.7000
   3.9500    4.2000    4.4500    4.7000    4.9500    5.2000    5.4500    5.7000
2.12      1.836     1.725     1.644     1.579     1.526     1.481     1.443
1.41      1.384     1.359     1.294     1.252     1.213     1.177     1.144
1.118     1.087     1.062      1.041     1.022     1.005      .991      .971
 .965      .9612      .96       .9612     .965      .971      .98       .991
1.005     1.022     1.041     1.062     1.087     1.141     1.207     1.275
1.341     1.403     1.475     1.542     1.609     1.676     1.745     1.81
1.877     1.944     2.011     2.078     2.145     2.212     2.279     2.346
  63.0272   47.0520   66.7956   66.5103   66.1966   65.8548   65.6735   65.2909
  63.0094   60.8014   64.2105   63.7452   62.9095   62.1812   61.3230   60.4173
  59.1408   58.1354   56.7370   55.2770   53.7650   51.8119   50.2070   46.0828
  43.9854   41.8818   39.5320   37.7022   35.2406   32.8332   30.4938   28.2340
  26.0634   23.9058   22.0187   20.1543   18.3987   14.7287   12.0469    9.7675
   8.1308    6.7446    5.8104    4.9754    4.2493    3.7692    3.3392    2.8361
   2.5063    2.2127    2.0355    1.7947    1.5813    1.4524    1.3338    1.2247
 909.7600  904.0700  902.5600  900.8800  899.0100  896.3800  895.8900  893.5900
 692.3700  691.1100  687.0700  884.1500  879.4600  874.3700  868.9000  863.0400
 854.6400  847.8900  838.3100  828.0600  817.1500  802.6000  790.2400  756.5600
 738.2800  719.0600  686.3900  677.8600  651.4400  623.7800  594.9200  564.9100
 883.7900  801.5900  468.3700  434.1800  399.9600  313.8100  237.4700  158.6300
  91.3620   22.9990  -32.2740  -87.8880 -143.6800 -185.5400 -227.3400 -282.8700
-324.2600 -365.3700 -392.5900 -833.0900 -473.1900 -499.7200 -526.0000 -552.0100
    .0000   855.8000  625.1000  694.4000  763.6000  832.8000  867.4000  936.4000
 970.9000 1005.0000 1109.0000 1178.0000 1281.0000 1383.0000 1486.0000 1588.0000
1724.0000 1826.0000 1961.0000 2096.0000 2229.0000 2396.0000 2528.0000 2856.0000
3018.0000 3179.0000 3433.0000 3496.0000 3683.0000 3869.0000 4052.0000 4233.0000
4411.0000 4587.0000 4670.0000 4931.0000 5100.0000 5483.0000 5799.0000 6105.0000
6351.0000 6590.0000 6775.0000 6955.0000 7131.0000 7259.0000 7385.0000 7548.0000
7667.0000 7784.0000 7860.0000 7972.0000 8081.0000 8153.0000 8223.0000 8292.0000
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
4939.     4939.     4939.     4939.     4939.     4939.     4939.     4939.
```

9 18 1

1.

-.26467+04	.90000+03	.28803+02	.34863+00	-.33776-01	.14746-04	.6444
-.24890+04	.12600+04	.27118+02	.92084+00	-.44521+00	.18310-04	.5702
-.19698+04	.16200+04	.22878+02	.11229+01	-.49873+00	.21204-04	.4607
-.17560+04	.19800+04	.22341+02	.44314+00	-.34915-02	.24115-04	.4643
-.15994+04	.23400+04	.22337+02	.43167+00	-.10821-02	.26909-04	.4746
-.14428+04	.27000+04	.22327+02	.44164+00	-.62140-02	.29568-04	.4815
-.12754+04	.30600+04	.22294+02	.46737+00	-.18097-01	.32096-04	.4871
-.11871+04	.34200+04	.22236+02	.48845+00	-.27994-01	.34526-04	.4920
-.92709+03	.37800+04	.22165+02	.51522+00	-.38272-01	.36867-04	.4954
-.7 125+03	.41400+04	.22064+02	.58244+00	-.66579-01	.39124-04	.4969
-.4 835+03	.45000+04	.21888+02	.72845+00	-.13551+00	.41296-04	.4959
-.3 171+03	.48600+04	.21557+02	.10032+01	-.27779+00	.43365-04	.4907
.4955+03	.52200+04	.20958+02	.14912+01	-.53823+00	.45303-04	.4799
.1611+03	.55800+04	.19964+02	.22588+01	-.94797+00	.47063-04	.4613
.19008+04	.59400+04	.18529+02	.32253+01	-.14434+01	.48603-04	.4346
.32249+04	.63000+04	.16811+02	.40748+01	-.18315+01	.49928-04	.4035
.47678+04	.66600+04	.15126+02	.48751+01	-.19062+01	.51117-04	.3746
.69580+04	.72000+04	.13287+02	.35309+01	-.14271+01	.52916-04	.3437

5.

-.26490+04	.90000+03	.28854+02	.32882+00	-.15201-01	.14748-04	.6475
-.24880+04	.12600+04	.28006+02	.64148+00	-.23925+00	.18362-04	.6059
-.21267+04	.16200+04	.24688+02	.13832+01	-.78274+00	.21886-04	.5082
-.17627+04	.19800+04	.22408+02	.52364+00	-.74456-01	.24148-04	.4660
-.15998+04	.23400+04	.22339+02	.43147+00	-.19553-02	.26910-04	.4746
-.14445+04	.27000+04	.22333+02	.43397+00	-.30831-02	.29563-04	.4813
-.12856+04	.30600+04	.22316+02	.45125+00	-.10426-01	.32099-04	.4861
-.11190+04	.34200+04	.22278+02	.47342+00	-.20529-01	.34552-04	.4904
-.94513+03	.37800+04	.22223+02	.49298+00	-.28673-01	.36876-04	.4941
-.76260+03	.41400+04	.22154+02	.52492+00	-.41386-01	.39141-04	.4965
-.58314+03	.45000+04	.22055+02	.59064+00	-.71052-01	.41331-04	.4973
-.33145+03	.48600+04	.21889+02	.70821+00	-.13265+00	.43442-04	.4957
-.42780+02	.52200+04	.21604+02	.91314+00	-.24632+00	.45466-04	.4913
.34111+03	.55800+04	.21129+02	.12437+01	-.43650+00	.47382-04	.4830
.87115+03	.59400+04	.20391+02	.17263+01	-.71892+00	.49164-04	.4693
.18990+04	.63000+04	.19351+02	.23309+01	-.10701+01	.50785-04	.4499
.25509+04	.66600+04	.18058+02	.29462+01	-.14121+01	.52289-04	.4261
.43277+04	.72000+04	.15963+02	.38308+01	-.16896+01	.54168-04	.3892

10.

-.26495+04	.90000+03	.28866+02	.31416+00	-.10724-01	.14749-04	.6482
-.25008+04	.12600+04	.28249+02	.56284+00	-.17726+00	.18576-04	.6160
-.21925+04	.16200+04	.25549+02	.12151+01	-.68520+00	.21466-04	.5330
-.17797+04	.19800+04	.22579+02	.69741+00	-.22909+00	.24144-04	.4702
-.16008+04	.23400+04	.22344+02	.43581+00	-.59166-02	.26910-04	.4748
-.14480+04	.27000+04	.22335+02	.43217+00	-.25115-02	.29564-04	.4812
-.12873+04	.30600+04	.22322+02	.44597+00	-.79521-02	.32100-04	.4859
-.11280+04	.34200+04	.22292+02	.46683+00	-.17126-01	.34534-04	.4899
-.95145+03	.37800+04	.22244+02	.48604+00	-.25321-01	.36879-04	.4934
-.77240+03	.41400+04	.22184+02	.51098+00	-.35093-01	.39146-04	.4960
-.58083+03	.45000+04	.22103+02	.55846+00	-.55853-01	.41340-04	.4973
-.46647+03	.48600+04	.21976+03	.64052+00	-.98824-01	.43462-04	.4966

-.11247+03	.52200+04	.21766+02	.78260+00	-.17815+00	.45806-04	.4938
.20731+03	.55800+04	.21422+02	.10106+01	-.31158+00	.47460-04	.4881
.42858+03	.59400+04	.20885+02	.18490+01	-.81568+00	.49304-04	.4784
.11921+04	.63000+04	.20165+02	.17982+01	-.79818+00	.51019-04	.4639
.19389+04	.66600+04	.19079+02	.23101+01	-.10999+01	.52587-04	.4447
.43727+04	.72000+04	.17232+02	.29880+01	-.14849+01	.54678-04	.4114
20.						
-.26499+04	.90000+03	.28875+02	.38946+00	-.75496-02	.14749-04	.6488
-.25181+04	.12600+04	.28430+02	.50316+00	-.12560+00	.18386-04	.6237
-.22459+04	.16200+04	.26308+02	.10317+01	-.35651+00	.21532-04	.5561
-.18221+04	.19800+04	.23015+02	.97447+00	-.48448+00	.24197-04	.4812
-.16020+04	.23400+04	.22362+02	.44962+00	-.21289-01	.26918-04	.4752
-.14454+04	.27000+04	.22338+02	.43142+00	-.27953-02	.29564-04	.4812
-.12886+04	.30600+04	.22327+02	.44182+00	-.60799-02	.32100-04	.4857
-.11263+04	.34200+04	.22303+02	.46058+00	-.13892-01	.34535-04	.4894
-.95699+03	.37800+04	.22263+02	.47963+00	-.22029-01	.36882-04	.4928
-.78077+03	.41400+04	.22211+02	.50057+00	-.30218-01	.39151-04	.4954
-.59487+03	.45000+04	.22143+02	.53567+00	-.44982-01	.41348-04	.4971
-.39269+03	.48600+04	.22044+02	.59317+00	-.75008-01	.43477-04	.4970
-.16282+03	.52200+04	.21887+02	.69214+00	-.13039+00	.45535-04	.4954
.11270+03	.55800+04	.21637+02	.84992+00	-.22368+00	.47519-04	.4915
.45842+03	.59400+04	.21247+02	.10849+01	-.36840+00	.49406-04	.4848
.90437+03	.63000+04	.20675+02	.14068+01	-.57203+00	.51189-04	.4743
.14800+04	.66600+04	.19893+02	.18000+01	-.82368+00	.52851-04	.4597
.26204+04	.72000+04	.18374+02	.24146+01	-.12101+01	.55105-04	.4317
30.						
-.26801+04	.90000+03	.28879+02	.38737+00	-.61323-02	.14750-04	.6498
-.25194+04	.12600+04	.28512+02	.47588+00	-.10738+00	.18391-04	.6273
-.22716+04	.16200+04	.26691+02	.93452+00	-.48602+00	.21564-04	.5602
-.18600+04	.19800+04	.23420+02	.11013+01	-.61087+00	.24245-04	.4916
-.16047+04	.23400+04	.22389+02	.47254+00	-.45157-01	.26916-04	.4759
-.14457+04	.27000+04	.22341+02	.43167+00	-.38956-02	.29564-04	.4812
-.12892+04	.30600+04	.22330+02	.43992+00	-.53087-02	.32101-04	.4856
-.11279+04	.34200+04	.22309+02	.45725+00	-.12168-01	.34536-04	.4892
-.95987+03	.37800+04	.22273+02	.47601+00	-.20111-01	.36884-04	.4924
-.78512+03	.41400+04	.22225+02	.49557+00	-.27782-01	.39153-04	.4951
-.60181+03	.45000+04	.22163+02	.52548+00	-.40062-01	.41352-04	.4968
-.40503+03	.48600+04	.22077+02	.57230+00	-.64435-01	.43484-04	.4971
-.18575+03	.52200+04	.21944+02	.65258+00	-.10935+00	.45549-04	.4960
.70484+02	.55800+04	.21735+02	.78007+00	-.18499+00	.47541-04	.4930
.38338+03	.59400+04	.21412+02	.96975+00	-.30281+00	.49451-04	.4876
.77748+03	.63000+04	.20936+02	.12321+01	-.47127+00	.51267-04	.4790
.12786+04	.66600+04	.20278+02	.15615+01	-.68714+00	.52973-04	.4668
.22698+04	.72000+04	.18955+02	.21104+01	-.10472+01	.55312-04	.4422
40.						
-.26502+04	.90000+03	.28881+02	.30614+00	-.52886-02	.14750-04	.6491
-.25169+04	.12600+04	.28562+02	.45924+00	-.93794-01	.18394-04	.6294
-.22875+04	.16200+04	.26936+02	.87210+00	-.43765+00	.21583-04	.5761
-.18908+04	.19800+04	.23760+02	.11503+01	-.66692+00	.24284-04	.5004
-.16082+04	.23400+04	.22424+02	.50171+00	-.75503-01	.26921-04	.4768
-.14461+04	.27000+04	.22343+02	.43299+00	-.55823-02	.29565-04	.4813
-.12896+04	.30600+04	.22332+02	.43882+00	-.49488-02	.32101-04	.4856
-.11289+04	.34200+04	.22313+02	.45502+00	-.11052-01	.34537-04	.4891
-.96175+03	.37800+04	.22279+02	.47349+00	-.18760-01	.36885-04	.4922
-.78799+03	.41400+04	.22234+02	.49235+00	-.26175-01	.39155-04	.4948
-.60628+03	.45000+04	.22177+02	.51933+00	-.37063-01	.41355-04	.4967
-.41273+03	.48600+04	.22098+02	.55987+00	-.58117-01	.43489-04	.4971

-.19973+03	.52200+04	.21979+02	.62914+00	-.96826-01	.45557-04	.4962
.45098+02	.55800+04	.21794+02	.78885+00	-.16202+00	.47556-04	.4938
.33864+03	.59400+04	.21612+02	.90163+00	-.26373+00	.49478-04	.4892
.70207+03	.63000+04	.21435+02	.11282+01	-.41084+00	.51313-04	.4818
.11585+04	.66600+04	.20515+02	.14166+01	-.60199+00	.53047-04	.4711
.20566+04	.72000+04	.19326+02	.19151+01	-.93781+00	.55441-04	.4490
80.						
-.26503+04	.90000+03	.28883+02	.30532+00	-.47065-02	.14750-04	.6492
-.25186+04	.12600+04	.28597+02	.44777+00	-.84364-01	.18396-04	.6309
-.22987+04	.16200+04	.27111+02	.82755+00	-.40227+00	.21597-04	.5817
-.19157+04	.19800+04	.24043+02	.11645+01	-.68970+00	.24317-04	.5078
-.16125+04	.23400+04	.22467+02	.53497+00	-.11016+00	.26927-04	.4779
-.14464+04	.27000+04	.22347+02	.43461+00	-.77871-02	.29565-04	.4814
-.12899+04	.30600+04	.22333+02	.43818+00	-.48151-02	.32101-04	.4856
-.11296+04	.34200+04	.22315+02	.45341+00	-.10260-01	.34537-04	.4896
-.96312+03	.37800+04	.22284+02	.47158+00	-.17729-01	.36885-04	.4920
-.79018+03	.41400+04	.22241+02	.49001+00	-.24981-01	.39156-04	.4946
-.60952+03	.45000+04	.22187+02	.51508+00	-.34971-01	.41356-04	.4965
-.41818+03	.48600+04	.22113+02	.55138+00	-.53788-01	.43492-04	.4970
-.28947+03	.52200+04	.22004+02	.61320+00	-.86289-01	.45563-04	.4964
.27627+02	.55800+04	.21836+02	.71090+00	-.14639+00	.47567-04	.4945
.30806+03	.59400+04	.21581+02	.85585+00	-.23710+00	.49497-04	.4903
.69069+03	.63000+04	.21205+02	.10576+01	-.36849+00	.51345-04	.4837
.10765+04	.66600+04	.20680+02	.13169+01	-.54245+00	.53098-04	.4740
.19096+04	.72000+04	.19590+02	.17762+01	-.83611+00	.55552-04	.4537
60.						
-.26503+04	.9[illegible]000+03	.28884+02	.30468+00	-.42707-02	.14750-04	.6498
-.25199+04	.12600+04	.28623+02	.43925+00	-.77832-01	.18397-04	.6321
-.23071+04	.16200+04	.27244+02	.79360+00	-.37484+00	.21608-04	.5861
-.19365+04	.19800+04	.24282+02	.11626+01	-.69611+00	.24344-04	.5141
-.16173+04	.23400+04	.22515+02	.57032+00	-.14712+00	.26933-04	.4791
-.14468+04	.27000+04	.22351+02	.43670+00	-.10475-01	.29566-04	.4815
-.12902+04	.30600+04	.22334+02	.43769+00	-.48324-02	.32101-04	.4856
-.11302+04	.34200+04	.22317+02	.45218+00	-.96680-02	.34537-04	.4889
-.96419+03	.37800+04	.22288+02	.47005+00	-.16903-01	.36886-04	.4919
-.79179+03	.41400+04	.22247+02	.48818+00	-.24038-01	.39157-04	.4944
-.61203+03	.45000+04	.22194+02	.51190+00	-.33392-01	.41358-04	.4964
-.42288+03	.48600+04	.22124+02	.54511+00	-.50578-01	.43494-04	.4970
-.21678+03	.52200+04	.22023+02	.60144+00	-.81988-01	.45567-04	.4965
.14627+02	.55800+04	.21867+02	.69038+00	-.13487+00	.47575-04	.4947
.28544+03	.59400+04	.21632+02	.82212+00	-.21747+00	.49511-04	.4918
.61888+03	.63000+04	.21287+02	.10087+01	-.33769+00	.51369-04	.4850
.10168+04	.66600+04	.20803+02	.12481+01	-.49778+00	.53134-04	.4762
.18003+04	.72000+04	.19790+02	.16708+01	-.79340+00	.55600-04	.4574
70.						
-.26804+04	.90000+03	.28885+02	.30420+00	-.39357-02	.14750-04	.6493
-.25209+04	.12600+04	.28648+02	.43258+00	-.71809-01	.18398-04	.6329
-.22137+04	.16200+04	.27350+02	.76659+00	-.35271+00	.21616-04	.5895
-.19336+04	.19800+04	.24486+02	.11531+01	-.69411+00	.24366-04	.5195
-.16226+04	.23400+04	.22568+02	.60611+00	-.18469+00	.26961-04	.4805
-.14472+04	.27000+04	.22355+02	.43919+00	-.13621-01	.29567-04	.4816
-.12904+04	.30600+04	.22336+02	.43748+00	-.49605-02	.32102-04	.4856
-.11306+04	.34200+04	.22319+02	.45120+00	-.92120-02	.34538-04	.4888
-.96805+03	.37800+04	.22291+02	.46870+00	-.16219-01	.36886-04	.4917
-.79310+03	.41400+04	.22251+02	.48669+00	-.23250-01	.39157-04	.4943
-.61407+03	.45000+04	.22201+02	.50939+00	-.32138-01	.41359-04	.4962
-.42568+03	.48600+04	.22134+02	.54023+00	-.48074-01	.43496-04	.4969

-.22255+03	.52200+04	.22037+02	.59236+00	-.77089-01	.45571-04	.4966
.44459+01	.55800+04	.21892+02	.67448+00	-.12592+00	.47581-04	.4950
.26781+03	.59400+04	.21673+02	.79603+00	-.20223+00	.49522-04	.4916
.58336+03	.63000+04	.21351+02	.96546+00	-.31336+00	.51387-04	.4861
.96908+03	.66600+04	.20900+02	.11856+01	-.46272+00	.53166-04	.4779
.17151+04	.72000+04	.19950+02	.15874+01	-.74292+00	.55653-04	.4603

SAMPLE PROBLEM 2 OUTPUT

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

```
NUMBER OF MATERIALS =    1
CM/CH =      .76168
ISENTROPIC EXPONENT =     1.16490


MATL            BTS             BTH             BLS             BLH
  1             .35000          .35000          .50000          .50000


NS = 56
IBRUPT =  1
NREYCR =  7
IPRNT =  2
OLTRAN =      .00000  INCHES


ABRUPT TRANSITION

FLOW IS TURBULENT
```

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

THERMODYNAMIC TABLE

PRESSURE = 1.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2646.7000	900.0000	28.8030	.000015	.6444
-2439.0000	1260.0000	27.1180	.000018	.5702
-1969.6000	1620.0000	22.8780	.000021	.4607
-1756.0000	1980.0000	22.3410	.000024	.4643
-1599.4000	2340.0000	22.3370	.000027	.4746
-1442.8000	2700.0000	22.3270	.000030	.4815
-1279.4000	3060.0000	22.2940	.000032	.4871
-1107.1000	3420.0000	22.2360	.000035	.4920
-927.0900	3780.0000	22.1650	.000037	.4954
-731.2500	4140.0000	22.0640	.000039	.4969
-498.3500	4500.0000	21.8880	.000041	.4959
-191.7100	4860.0000	21.5570	.000043	.4907
249.5500	5220.0000	20.9580	.000045	.4799
916.1100	5580.0000	19.9640	.000047	.4613
1900.8000	5940.0000	18.5290	.000049	.4346
3224.9000	6300.0000	16.8110	.000050	.4035
4767.8000	6660.0000	15.1260	.000051	.3746
6958.0000	7200.0000	13.2370	.000053	.3437

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 5.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2649.0000	900.0000	28.8540	.000015	.6475
-2488.0000	1260.0000	28.0060	.000018	.6059
-2126.7000	1620.0000	24.6880	.000021	.5082
-1762.7000	1980.0000	22.4080	.000024	.4660
-1599.8000	2340.0000	22.3390	.000027	.4746
-1444.5000	2700.0000	22.3330	.000030	.4813
-1283.6000	3060.0000	22.3160	.000032	.4861
-1119.0000	3420.0000	22.2780	.000035	.4904
-945.1300	3780.0000	22.2230	.000037	.4941
-762.6000	4140.0000	22.1540	.000039	.4965
-563.1400	4500.0000	22.0550	.000041	.4973
-331.4500	4860.0000	21.8890	.000043	.4957
-42.7800	5220.0000	21.6040	.000045	.4913
341.1100	5580.0000	21.1290	.000047	.4830
871.1500	5940.0000	20.3910	.000049	.4693
1599.0000	6300.0000	19.3510	.000051	.4499
2550.9000	6660.0000	18.0580	.000052	.4261
4327.7000	7200.0000	15.9630	.000054	.3892

PRESSURE = 10.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2649.5003	900.0000	28.8660	.000015	.6482
-2500.8000	1260.0000	28.2490	.000018	.6160
-2192.3000	1620.0000	25.5490	.000021	.5330
-1779.7000	1980.0000	22.5790	.000024	.4702
-1600.3000	2340.0000	22.3440	.000027	.4748
-1445.0000	2700.0000	22.3350	.000030	.4812
-1287.3000	3060.0000	22.3220	.000032	.4859
-1123.0000	3420.0000	22.2920	.000035	.4899
-951.4500	3780.0000	22.2440	.000037	.4934
-772.4000	4140.0000	22.1840	.000039	.4960
-580.8300	4500.0000	22.1030	.000041	.4973
-366.4700	4860.0000	21.9760	.000043	.4966
-112.4700	5220.0000	21.7660	.000046	.4938
207.3100	5580.0000	21.4220	.000047	.4881
628.5000	5940.0000	20.8830	.000049	.4784
1192.1000	6300.0000	20.1030	.000051	.4639
1980.9000	6660.0000	19.0790	.000053	.4447
3372.7000	7200.0000	17.2320	.000055	.4114

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 20.000ATM

EN H .PY (B /LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2 .9000	900.0000	28.8750	.000015	.6488
-2 .1000	1260.0000	28.4300	.000018	.6257
.9.9000	1620.0000	26.3080	.000022	.5561
.22.1000	1980.0000	23.0150	.000024	.4812
.1602.0000	2340.0000	22.3620	.000027	.4752
-1445.4000	2700.0000	22.3380	.000030	.4812
-1286.6000	3060.0000	22.3270	.000032	.4857
-1126.3000	3420.0000	22.3030	.000035	.4894
-956.9900	3780.0000	22.2630	.000037	.4928
-780.7700	4140.0000	22.2110	.000039	.4954
-594.8700	4500.0000	22.1430	.000041	.4971
-392.6900	4860.0000	22.0440	.000043	.4970
-162.9200	5220.0000	21.8870	.000046	.4954
112.7000	5580.0000	21.6370	.000048	.4915
458.4200	5940.0000	21.2470	.000049	.4848
904.3700	6300.0000	20.6750	.000051	.4743
1480.0000	6660.0000	19.8930	.000053	.4597
2620.4000	7200.0000	18.3740	.000055	.4317

PRESSURE = 30.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2650.1000	900.0000	28.8790	.000015	.6498
-2514.4000	1260.0000	28.5120	.000018	.6273
-2271.6000	1620.0000	26.6910	.000022	.5682
-1860.0000	1980.0000	23.4200	.000024	.4916
-1604.7000	2340.0000	22.3690	.000027	.4759
-1445.7000	2700.0000	22.3410	.000030	.4812
-1289.2000	3060.0000	22.3300	.000032	.4856
-1127.9000	3420.0000	22.3090	.000035	.4892
-959.8700	3780.0000	22.2730	.000037	.4924
-785.1200	4140.0000	22.2250	.000039	.4951
-601.8100	4500.0000	22.1650	.000041	.4968
-405.0300	4860.0000	22.0770	.000043	.4971
-185.7500	5220.0000	21.9440	.000046	.4960
70.4840	5580.0000	21.7350	.000048	.4930
383.3800	5940.0000	21.4120	.000049	.4876
777.4800	6300.0000	20.9360	.000051	.4790
1278.6000	6660.0000	20.2780	.000053	.4668
2269.8000	7200.0000	18.9550	.000055	.4422

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 40.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2658.2000	900.0000	28.6810	.000015	.6491
-2516.9000	1260.0000	28.5620	.000018	.6296
-2287.5000	1620.0000	26.9360	.000022	.5761
-1894.8000	1980.0000	25.7600	.000024	.5004
-1608.2000	2340.0000	22.4240	.000027	.4768
-1446.1000	2700.0000	22.3430	.000030	.4813
-1289.6000	3060.0000	22.3320	.000032	.4856
-1128.9000	3420.0000	22.3150	.000035	.4891
-961.7500	3780.0000	22.2790	.000037	.4922
-787.9900	4140.0000	22.2340	.000039	.4948
-606.2800	4500.0000	22.1770	.000041	.4967
-412.7300	4860.0000	22.0980	.000043	.4971
-199.7300	5220.0000	21.9790	.000046	.4962
45.0980	5580.0000	21.7940	.000048	.4938
338.6400	5940.0000	21.5120	.000049	.4892
702.0700	6300.0000	21.0950	.000051	.4818
1158.5000	6660.0000	20.5150	.000053	.4711
2056.6000	7200.0000	19.3260	.000055	.4490

PRESSURE = 50.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2650.3000	900.0000	28.6830	.000015	.6492
-2518.6000	1260.0000	28.5970	.000018	.6309
-2298.7000	1620.0000	27.1110	.000022	.5817
-1915.7000	1980.0000	24.0450	.000024	.5078
-1612.5000	2340.0000	22.4670	.000027	.4779
-1446.4000	2700.0000	22.3470	.000030	.4814
-1289.9000	3060.0000	22.3330	.000032	.4856
-1129.6000	3420.0000	22.3150	.000035	.4890
-963.1200	3780.0000	22.2840	.000037	.4920
-790.1000	4140.0000	22.2410	.000039	.4946
-609.5200	4500.0000	22.1870	.000041	.4965
-418.1800	4860.0000	22.1130	.000043	.4970
-209.4700	5220.0000	22.0040	.000046	.4964
27.6270	5580.0000	21.8360	.000048	.4943
308.0600	5940.0000	21.5810	.000049	.4903
650.6900	6300.0000	21.2050	.000051	.4[illegible]
1076.5000	6660.0000	20.6800	.000055	.[illegible]
1909.6000	7200.0000	19.5900	[illegible]056	[illegible]537

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

PRESSURE = 60.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2659.3000	900.0000	28.8640	.000015	.6493
-2519.9000	1260.0000	28.6230	.000018	.6321
-2387.1000	1620.0000	27.2440	.000022	.5861
-1936.3000	1980.0000	24.2820	.000024	.5141
-1617.3000	2340.0000	22.5150	.000027	.4791
-1446.8000	2700.0000	22.3510	.000030	.4815
-1290.2000	3060.0000	22.3340	.000032	.4856
-1138.2000	3420.0000	22.3170	.000035	.4889
-969.1900	3780.0000	22.2880	.000037	.4919
-791.7500	4140.0000	22.2470	.000039	.4944
-612.0300	4500.0000	22.1940	.000041	.4964
-422.3300	4860.0000	22.1240	.000043	.4978
-216.7800	5220.0000	22.0230	.000046	.4985
14.6270	5580.0000	21.8670	.000048	.4987
285.4400	5940.0000	21.6350	.000050	.4910
612.8000	6300.0000	21.2870	.000051	.4859
1016.0000	6660.0000	20.8030	.000053	.4762
1600.3000	7200.0000	19.7900	.000056	.4574

PRESSURE = 70.000ATM

ENTHALPY (BTU/LBM)	TEMPERATURE (DEG R)	MOLECULAR WEIGHT	VISCOSITY (LB/SEC-FT)	PRANDTL NUMBER
-2658.4000	900.0000	28.8850	.000015	.6493
-2520.9000	1260.0000	28.6430	.000018	.6329
-2318.7000	1620.0000	27.3500	.000022	.5895
-1958.6000	1980.0000	24.4860	.000024	.5195
-1622.6000	2340.0000	22.5680	.000027	.4805
-1447.2000	2700.0000	22.3550	.000030	.4816
-1290.4000	3060.0000	22.3360	.000032	.4856
-1138.6000	3420.0000	22.3190	.000035	.4888
-969.0500	3780.0000	22.2910	.000037	.4917
-793.1000	4140.0000	22.2510	.000039	.4943
-614.0700	4500.0000	22.2010	.000041	.4962
-425.6500	4860.0000	22.1340	.000043	.4969
-222.9500	5220.0000	22.0370	.000046	.4966
4.4489	5580.0000	21.8920	.000048	.4950
267.8130	5940.0000	21.6730	.000050	.4916
583.3600	6300.0000	21.3510	.000051	.4861
969.0800	6660.0000	20.9000	.000053	.4779
1715.1000	7200.0000	19.9500	.000056	.4603

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

GENERAL INPUT INFORMATION

BODY PT NO (J)	INTEG PT NO (I)	MATL NO (MATL)	STREAM LENGTH INCH (S)	AXIAL LENGTH INCH (Z)	RADIAL LENGTH INCH (R)	BODY ANGLE DEG (THETB)	NORMALIZED ABLATION RATE (BPSP)	WALL TEMP DEG R (TW)	SURFACE ROUGHNESS MIL (RUFMIL)	---EDGE CONDITION--- PRESSURE ATM (PE)	ENTHALPY BTU/LBM (HE)	VELOCITY FT/SEC (UE)
1	1	1	.00	-2.250	2.120	-80.015	.000	4939.00	2.000	68.03	909.76	.00
2	2	1	.05	-2.242	2.073	-79.311	.000	4939.00	2.000	67.86	908.81	93.51
2	3	1	.10	-2.233	2.025	-78.608	.000	4939.00	2.000	67.70	907.86	187.32
2	4	1	.14	-2.225	1.978	-77.904	.000	4939.00	2.000	67.54	906.92	278.40
2	5	1	.19	-2.217	1.931	-77.201	.000	4939.00	2.000	67.38	905.97	370.87
2	6	1	.24	-2.208	1.883	-76.497	.000	4939.00	2.000	67.21	905.02	463.33
2	7	1	.29	-2.200	1.836	-75.793	.000	4939.00	2.000	67.05	904.07	555.80
3	8	1	.33	-2.183	1.799	-71.358	.000	4939.00	2.000	66.97	903.57	578.98
3	9	1	.37	-2.167	1.762	-66.923	.000	4939.00	2.000	66.88	903.06	602.00
3	10	1	.41	-2.150	1.725	-62.488	.000	4939.00	2.000	66.80	902.56	625.10
4	11	1	.46	-2.125	1.684	-59.040	.000	4939.00	2.000	66.65	901.72	659.75
4	12	1	.51	-2.100	1.644	-55.592	.000	4939.00	2.000	66.51	900.88	694.40
5	13	1	.55	-2.075	1.612	-52.656	.000	4939.00	2.000	66.35	899.94	729.00
5	14	1	.59	-2.050	1.579	-49.720	.000	4939.00	2.000	66.20	899.01	763.60
6	15	1	.62	-2.025	1.552	-47.071	.000	4939.00	2.000	66.03	897.99	798.20
6	16	1	.66	-2.000	1.526	-44.421	.000	4939.00	2.000	65.85	896.98	832.80
7	17	1	.69	-1.975	1.504	-42.057	.000	4939.00	2.000	65.76	896.43	850.10
7	18	1	.73	-1.950	1.481	-39.693	.000	4939.00	2.000	65.67	895.89	867.40
8	19	1	.76	-1.925	1.462	-37.534	.000	4939.00	2.000	65.48	894.74	901.90
8	20	1	.79	-1.900	1.443	-35.375	.000	4939.00	2.000	65.29	893.59	936.40
9	21	1	.82	-1.875	1.427	-32.958	.000	4939.00	2.000	65.19	892.98	953.65
9	22	1	.85	-1.850	1.410	-30.541	.000	4939.00	2.000	65.09	892.37	970.90
10	23	1	.88	-1.825	1.397	-27.935	.000	4939.00	2.000	64.99	891.74	987.98
10	24	1	.91	-1.800	1.384	-25.330	.000	4939.00	2.000	64.88	891.11	1005.00
11	25	1	.96	-1.750	1.361	-24.779	.000	4939.00	2.000	64.85	889.09	1057.00
11	26	1	1.02	-1.700	1.339	-24.228	.000	4939.00	2.000	64.22	887.07	1109.00
12	27	1	1.07	-1.650	1.316	-23.868	.000	4939.00	2.000	63.98	885.61	1148.50
12	28	1	1.13	-1.600	1.294	-23.509	.000	4939.00	2.000	63.75	884.15	1178.00
13	29	1	1.18	-1.550	1.273	-22.778	.000	4939.00	2.000	63.37	881.81	1229.50
13	30	1	1.23	-1.500	1.252	-22.048	.000	4939.00	2.000	62.99	879.46	1281.00
14	31	1	1.29	-1.450	1.233	-21.302	.000	4939.00	2.000	62.58	876.92	1332.00
14	32	1	1.34	-1.400	1.213	-20.556	.000	4939.00	2.000	62.18	874.37	1383.00
15	33	1	1.39	-1.350	1.195	-19.795	.000	4939.00	2.000	61.75	871.64	1434.50
15	34	1	1.45	-1.300	1.177	-19.034	.000	4939.00	2.000	61.32	868.90	1486.00
16	35	1	1.50	-1.250	1.161	-18.259	.000	4939.00	2.000	60.87	865.97	1537.00
16	36	1	1.55	-1.200	1.144	-17.484	.000	4939.00	2.000	60.42	863.04	1588.00
17	37	1	1.61	-1.150	1.129	-16.696	.000	4939.00	2.000	59.78	858.84	1656.50
17	38	1	1.66	-1.100	1.114	-15.908	.000	4939.00	2.000	59.14	854.64	1724.00
18	39	1	1.71	-1.050	1.100	-15.241	.000	4939.00	2.000	58.64	851.26	1775.00
18	40	1	1.76	-1.000	1.087	-14.574	.000	4939.00	2.000	58.14	847.89	1826.00
19	41	1	1.81	-.950	1.074	-13.763	.000	4939.00	2.000	57.45	843.10	1893.50
19	42	1	1.86	-.900	1.062	-12.953	.000	4939.00	2.000	56.74	838.31	1961.00
20	43	1	1.92	-.850	1.052	-12.131	.000	4939.00	2.000	56.00	833.18	2028.50
20	44	1	1.97	-.800	1.041	-11.310	.000	4939.00	2.000	55.28	828.06	2096.00

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	MATL NO (MATL)	STREAM LENGTH INCH (S)	AXIAL LENGTH INCH (Z)	RADIAL LENGTH INCH (R)	BODY ANGLE DEG (THETB)	NORMALIZED ABLATION RATE (BPSP)	WALL TEMP DEG R (TW)	SURFACE ROUGHNESS MIL (RUFMIL)	---EDGE CONDITION--- PRESSURE ATM (PE)	ENTHALPY BTU/LBM (HE)	VELOCITY FT/SEC (UE)
21	45	1	2.02	-.750	1.031	-10.757	.000	4939.00	2.000	54.52	822.60	2162.50
21	46	1	2.07	-.700	1.022	-10.204	.000	4939.00	2.000	53.76	817.15	2229.00
22	47	1	2.12	-.650	1.013	-9.507	.000	4939.00	2.000	52.78	809.87	2312.50
22	48	1	2.17	-.600	1.005	-8.811	.000	4939.00	2.000	51.81	802.60	2396.00
23	49	1	2.22	-.550	.998	-7.638	.000	4939.00	2.000	51.00	796.42	2462.00
23	50	1	2.27	-.500	.991	-6.466	.000	4939.00	2.000	50.21	790.24	2528.00
24	51	1	2.34	-.433	.984	-5.962	.000	4939.00	2.000	48.79	779.01	2637.33
24	52	1	2.40	-.367	.978	-5.457	.000	4939.00	2.000	47.42	767.79	2746.67
24	53	1	2.47	-.300	.971	-4.953	.000	4939.00	2.000	46.08	756.56	2856.00
25	54	1	2.52	-.250	.968	-3.879	.000	4939.00	2.000	45.02	747.42	2937.00
25	55	1	2.57	-.200	.965	-2.805	.000	4939.00	2.000	43.99	738.28	3018.00
26	56	1	2.62	-.150	.963	-2.119	.000	4939.00	2.000	42.92	728.67	3098.50
26	57	1	2.67	-.100	.961	-1.432	.000	4939.00	2.000	41.88	719.06	3179.00
27	58	1	2.72	-.050	.961	-.716	.000	4939.00	2.000	40.17	702.72	3306.00
27	59	1	2.77	.000	.960	.000	.000	4939.00	2.000	38.58	686.39	3433.00
28	60	1	2.82	.050	.961	.716	.000	4939.00	2.000	38.11	682.12	3464.50
28	61	1	2.87	.100	.961	1.432	.000	4939.00	2.000	37.70	677.86	3496.00
29	62	1	2.92	.150	.963	2.119	.000	4939.00	2.000	36.45	664.65	3589.50
29	63	1	2.97	.200	.965	2.805	.000	4939.00	2.000	35.24	651.44	3683.00
30	64	1	3.02	.250	.968	3.547	.000	4939.00	2.000	34.02	637.61	3776.00
30	65	1	3.07	.300	.971	4.289	.000	4939.00	2.000	32.83	623.78	3869.00
31	66	1	3.12	.350	.975	5.000	.000	4939.00	2.000	31.64	609.35	3960.50
31	67	1	3.17	.400	.980	5.711	.000	4939.00	2.000	30.49	594.92	4052.00
32	68	1	3.22	.450	.985	6.418	.000	4939.00	2.000	29.34	579.92	4142.50
32	69	1	3.27	.500	.991	7.125	.000	4939.00	2.000	28.23	564.91	4233.00
33	70	1	3.32	.550	.998	7.968	.000	4939.00	2.000	27.13	549.35	4322.00
33	71	1	3.37	.600	1.005	8.811	.000	4939.00	2.000	26.06	533.79	4411.00
34	72	1	3.42	.650	1.013	9.507	.000	4939.00	2.000	25.01	517.69	4499.00
34	73	1	3.48	.700	1.022	10.204	.000	4939.00	2.000	23.99	501.59	4587.00
35	74	1	3.53	.750	1.031	10.757	.000	4939.00	2.000	22.98	484.98	4628.50
35	75	1	3.58	.800	1.041	11.310	.000	4939.00	2.000	22.02	468.37	4670.00
36	76	1	3.63	.850	1.051	12.131	.000	4939.00	2.000	21.07	451.27	4800.50
36	77	1	3.68	.900	1.062	12.953	.000	4939.00	2.000	20.15	434.18	4931.00
37	78	1	3.73	.950	1.074	13.853	.000	4939.00	2.000	19.26	416.62	5015.50
37	79	1	3.78	1.000	1.087	14.753	.000	4939.00	2.000	18.40	399.06	5100.00
38	80	1	3.85	1.067	1.105	14.812	.000	4939.00	2.000	17.08	370.64	5227.67
38	81	1	3.92	1.133	1.123	14.872	.000	4939.00	2.000	15.86	342.23	5355.33
38	82	1	3.99	1.200	1.141	14.931	.000	4939.00	2.000	14.73	313.81	5483.00
39	83	1	4.08	1.283	1.163	14.955	.000	4939.00	2.000	13.77	288.36	5588.33
39	84	1	4.16	1.367	1.185	14.979	.000	4939.00	2.000	12.88	262.92	5693.67
39	85	1	4.25	1.450	1.207	15.003	.000	4939.00	2.000	12.05	237.47	5799.00
40	86	1	4.33	1.533	1.230	15.003	.000	4939.00	2.000	11.23	211.19	5901.00
40	87	1	4.42	1.617	1.252	15.003	.000	4939.00	2.000	10.47	184.91	6003.00
40	88	1	4.51	1.700	1.275	15.003	.000	4939.00	2.000	9.77	158.63	6105.00
41	89	1	4.59	1.783	1.297	14.967	.000	4939.00	2.000	9.28	136.21	6187.00
41	90	1	4.68	1.867	1.319	14.931	.000	4939.00	2.000	8.66	113.78	6269.00
41	91	1	4.77	1.950	1.341	14.896	.000	4939.00	2.000	8.15	91.36	6351.00

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	MATL NO (MATL)	STREAM LENGTH INCH (S)	AXIAL LENGTH INCH (Z)	RADIAL LENGTH INCH (R)	BODY ANGLE DEG (THETB)	NORMALIZED ABLATION RATE (BPSP)	WALL TEMP DEG R (TW)	SURFACE ROUGHNESS MIL (RUFMIL)	---EDGE CONDITION--- PRESSURE ATM (PE)	ENTHALPY BTU/LBM (HE)	VELOCITY FT/SEC (UE)
92	92	1	4.85	2.033	1.363	14.931	.000	4939.00	2.000	7.66	68.57	6430.67
92	93	1	4.94	2.117	1.386	14.967	.000	4939.00	2.000	7.20	45.79	6510.33
92	94	1	5.02	2.200	1.408	15.003	.000	4939.00	2.000	6.77	23.00	6590.00
93	95	1	5.11	2.283	1.430	15.003	.000	4939.00	2.000	6.48	4.57	6691.67
93	96	1	5.20	2.367	1.453	15.003	.000	4939.00	2.000	6.11	-18.85	6718.33
93	97	1	5.28	2.450	1.475	15.003	.000	4939.00	2.000	5.81	-32.27	6776.00
94	98	1	5.37	2.533	1.497	15.003	.000	4939.00	2.000	5.52	-50.81	6835.00
94	99	1	5.46	2.617	1.520	15.003	.000	4939.00	2.000	5.24	-69.35	6895.00
94	100	1	5.54	2.700	1.542	15.003	.000	4939.00	2.000	4.98	-87.89	6955.00
95	101	1	5.63	2.783	1.564	15.003	.000	4939.00	2.000	4.72	-106.49	7018.67
95	102	1	5.72	2.867	1.587	15.003	.000	4939.00	2.000	4.48	-125.08	7072.33
95	103	1	5.80	2.950	1.609	15.003	.000	4939.00	2.000	4.25	-143.68	7131.00
96	104	1	5.89	3.033	1.631	15.003	.000	4939.00	2.000	4.08	-157.63	7178.67
96	105	1	5.97	3.117	1.654	15.003	.000	4939.00	2.000	3.92	-171.59	7216.33
96	106	1	6.06	3.200	1.676	15.003	.000	4939.00	2.000	3.77	-185.54	7259.00
97	107	1	6.15	3.283	1.698	15.003	.000	4939.00	2.000	3.62	-199.47	7301.00
97	108	1	6.23	3.367	1.721	15.003	.000	4939.00	2.000	3.48	-213.41	7343.00
97	109	1	6.32	3.450	1.743	15.003	.000	4939.00	2.000	3.34	-227.34	7385.00
98	110	1	6.41	3.533	1.765	15.003	.000	4939.00	2.000	3.16	-245.85	7439.33
98	111	1	6.49	3.617	1.788	15.003	.000	4939.00	2.000	2.99	-264.36	7493.67
98	112	1	6.58	3.700	1.810	15.003	.000	4939.00	2.000	2.84	-282.87	7548.00
99	113	1	6.66	3.783	1.832	15.003	.000	4939.00	2.000	2.72	-296.67	7587.67
99	114	1	6.75	3.867	1.855	15.003	.000	4939.00	2.000	2.61	-310.46	7627.33
99	115	1	6.84	3.950	1.877	15.003	.000	4939.00	2.000	2.51	-324.26	7667.00
50	116	1	6.92	4.033	1.899	15.003	.000	4939.00	2.000	2.40	-337.96	7706.00
50	117	1	7.01	4.117	1.922	15.003	.000	4939.00	2.000	2.31	-351.67	7745.00
50	118	1	7.10	4.200	1.944	15.003	.000	4939.00	2.000	2.21	-365.37	7784.00
51	119	1	7.18	4.283	1.966	15.003	.000	4939.00	2.000	2.15	-374.44	7809.33
51	120	1	7.27	4.367	1.989	15.003	.000	4939.00	2.000	2.09	-383.52	7834.67
51	121	1	7.35	4.450	2.011	15.003	.000	4939.00	2.000	2.04	-392.59	7860.00
52	122	1	7.44	4.533	2.033	15.003	.000	4939.00	2.000	1.95	-406.09	7897.33
52	123	1	7.53	4.617	2.056	15.003	.000	4939.00	2.000	1.87	-419.59	7934.67
52	124	1	7.61	4.700	2.078	15.003	.000	4939.00	2.000	1.79	-433.09	7972.00
53	125	1	7.70	4.783	2.100	15.003	.000	4939.00	2.000	1.72	-446.46	8008.33
53	126	1	7.79	4.867	2.123	15.003	.000	4939.00	2.000	1.65	-459.82	8044.67
53	127	1	7.87	4.950	2.145	15.003	.000	4939.00	2.000	1.58	-473.19	8081.00
54	128	1	7.96	5.033	2.167	15.003	.000	4939.00	2.000	1.54	-482.03	8105.00
54	129	1	8.04	5.117	2.190	15.003	.000	4939.00	2.000	1.49	-490.88	8129.00
54	130	1	8.13	5.200	2.212	15.003	.000	4939.00	2.000	1.45	-499.72	8153.00
55	131	1	8.22	5.283	2.234	15.003	.000	4939.00	2.000	1.41	-508.48	8176.33
55	132	1	8.30	5.367	2.257	15.003	.000	4939.00	2.000	1.37	-517.24	8199.67
55	133	1	8.39	5.450	2.279	15.003	.000	4939.00	2.000	1.33	-526.00	8223.00
56	134	1	8.48	5.533	2.301	15.003	.000	4939.00	2.000	1.30	-534.67	8246.00
56	135	1	8.56	5.617	2.324	15.003	.000	4939.00	2.000	1.26	-543.34	8269.00
56	136	1	8.65	5.700	2.346	15.003	.000	4939.00	2.000	1.22	-552.01	8292.00

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - EDGE PROPERTIES

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	VELOCITY FT/SEC (UE)	MACH NO (HCAM)	ENTHALPY BTU/LBM (HE)	TEMPERATURE DEG R (TE)	DENSITY LBM/FT3 (RDE)	VISCOSITY LBM/FT-SEC (VISE)	UNIT RE NO 1/FT (URE)
1	1	.0000	.0	.0000	909.8	6597.1	2.960-01	5.285-05	0.000
	2	.0481	93.5	.0219	908.8	6595.5	2.953-01	5.284-05	5.227+05
	3	.0961	187.3	.0439	907.9	6594.0	2.947-01	5.283-05	1.045+06
	4	.1442	278.4	.0652	906.9	6592.5	2.941-01	5.283-05	1.550+06
	5	.1922	370.9	.0869	906.0	6591.0	2.934-01	5.282-05	2.060+06
	6	.2403	463.3	.1086	905.0	6589.5	2.928-01	5.281-05	2.569+06
2	7	.2884	555.8	.1303	904.1	6588.0	2.922-01	5.280-05	3.075+06
	8	.3289	578.9	.1357	903.6	6587.2	2.918-01	5.280-05	3.200+06
	9	.3695	602.0	.1411	903.1	6586.4	2.915-01	5.279-05	3.326+06
3	10	.4101	625.1	.1465	902.6	6585.6	2.912-01	5.279-05	3.448+06
	11	.4577	659.7	.1547	901.7	6584.3	2.906-01	5.278-05	3.632+06
4	12	.5053	694.4	.1628	900.9	6583.0	2.901-01	5.278-05	3.816+06
	13	.5463	729.0	.1710	899.9	6581.5	2.894-01	5.277-05	3.999+06
5	14	.5873	763.6	.1791	899.0	6580.0	2.888-01	5.276-05	4.180+06
	15	.6237	798.2	.1872	898.0	6578.5	2.882-01	5.275-05	4.360+06
6	16	.6602	832.8	.1954	897.0	6576.9	2.875-01	5.274-05	4.539+06
	17	.6938	850.1	.1995	896.4	6576.0	2.871-01	5.274-05	4.628+06
7	18	.7274	867.4	.2035	895.9	6575.2	2.868-01	5.274-05	4.717+06
	19	.7588	901.9	.2117	894.7	6573.4	2.860-01	5.273-05	4.893+06
8	20	.7902	936.4	.2198	893.6	6571.6	2.853-01	5.272-05	5.067+06
	21	.8202	953.7	.2239	893.0	6570.6	2.849-01	5.271-05	5.154+06
9	22	.8501	970.9	.2279	892.4	6569.7	2.845-01	5.271-05	5.241+06
	23	.8783	988.0	.2319	891.7	6568.7	2.841-01	5.270-05	5.329+06
10	24	.9065	1005.0	.2360	891.1	6567.7	2.837-01	5.270-05	5.418+06
	25	.9313	1057.0	.2482	889.1	6564.6	2.824-01	5.268-05	5.666+06
11	26	1.0162	1109.0	.2605	887.1	6561.5	2.811-01	5.266-05	5.919+06
	27	1.0710	1143.5	.2687	885.6	6559.2	2.801-01	5.265-05	6.084+06
12	28	1.1258	1178.0	.2768	884.2	6557.0	2.792-01	5.264-05	6.248+06
	29	1.1800	1229.5	.2890	881.8	6553.4	2.777-01	5.262-05	[illegible]+06
13	30	1.2343	1281.0	.3012	879.5	6549.8	2.762-01	5.260-05	727+06
	31	1.2879	1332.0	.3133	876.9	6545.9	2.747-01	5.258-05	[illegible]+06
14	32	1.3416	1383.0	.3254	874.4	6542.1	2.731-01	5.256-05	[illegible]+06
	33	1.3948	1434.5	.3377	871.6	6537.9	2.714-01	5.254-05	[illegible]+06
15	34	1.4479	1486.0	.3499	868.9	6533.8	2.697-01	5.252-05	[illegible]+06
	35	1.5006	1537.0	.3621	866.0	6529.4	2.679-01	5.250-05	[illegible]+06
16	36	1.5532	1588.0	.3742	863.0	6525.1	2.661-01	5.248-05	[illegible]
	37	1.6034	1656.0	.3904	858.8	6518.8	2.636-01	5.244-05	[illegible]
17	38	1.6576	1724.0	.4067	854.6	6512.3	2.610-01	5.241-05	[illegible]
	39	1.7094	1775.0	.4189	851.3	6507.2	2.590-01	5.238-05	[illegible]
18	40	1.7612	1826.0	.4311	847.9	6502.1	2.571-01	5.236-05	[illegible]
	41	1.8127	1893.5	.4474	843.4	6494.9	2.543-01	5.232-05	9.202+06
19	42	1.8643	1961.0	.4636	838.3	6487.7	2.515-01	5.228-05	9.433+06
	43	1.9154	2028.5	.4799	833.2	6480.2	2.486-01	5.224-05	9.652+06
20	44	1.9664	2096.0	.4962	828.1	6472.6	2.457-01	5.220-05	9.864+06

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	VELOCITY FT/SEC (UE)	MACH NO (HCAM)	ENTHALPY BTU/LBM (HE)	TEMPERATURE DEG R (TE)	DENSITY LBM/FT3 (ROE)	VISCOSITY LBM/FT-SEC (VISE)	UNIT RE NO 1/FT (URE)
	45	2.0173	2162.5	.5123	822.6	6464.7	2.426-01	5.216-05	1.086+07
21	46	2.0682	2229.0	.5284	817.2	6456.8	2.396-01	5.212-05	1.029+07
	47	2.1190	2312.5	.5487	809.9	6446.4	2.357-01	5.207-05	1.047+07
22	48	2.1697	2396.0	.5690	802.6	6436.1	2.318-01	5.201-05	1.068+07
	49	2.2202	2462.0	.5851	796.4	6427.4	2.285-01	5.197-05	1.082+07
23	50	2.2706	2528.0	.6013	790.2	6418.9	2.253-01	5.192-05	1.097+07
	51	2.3376	2637.3	.6282	779.0	6402.9	2.195-01	5.184-05	1.117+07
	52	2.4046	2746.7	.6551	767.8	6387.2	2.140-01	5.176-05	1.135+07
24	53	2.4716	2856.0	.6822	756.6	6371.7	2.085-01	5.168-05	1.152+07
	54	2.5217	2957.0	.7023	747.4	6359.4	2.042-01	5.162-05	1.162+07
25	55	2.5718	3018.0	.7225	738.3	6347.2	1.999-01	5.155-05	1.170+07
	56	2.6219	3098.5	.7426	728.7	6334.5	1.955-01	5.149-05	1.177+07
26	57	2.6719	3179.0	.7628	719.1	6322.1	1.912-01	5.143-05	1.183+07
	58	2.7219	3306.0	.7948	702.7	6301.4	1.841-01	5.132-05	1.186+07
27	59	2.7719	3433.0	.8272	686.4	6275.0	1.774-01	5.118-05	1.190+07
	60	2.8219	3464.5	.8353	682.1	6268.2	1.757-01	5.114-05	1.190+07
28	61	2.8719	3496.0	.8434	677.9	6261.3	1.740-01	5.111-05	1.190+07
	62	2.9219	3539.5	.8675	664.7	6240.5	1.689-01	5.100-05	1.189+07
29	63	2.9720	3683.0	.8918	651.4	6219.9	1.639-01	5.089-05	1.186+07
	64	3.0221	3776.0	.9160	637.6	6198.9	1.588-01	5.077-05	1.181+07
30	65	3.0722	3869.0	.9404	623.8	6178.2	1.538-01	5.067-05	1.178+07
	66	3.1224	3960.5	.9645	609.3	6157.1	1.488-01	5.055-05	1.166+07
31	67	3.1726	4052.0	.9886	594.9	6136.4	1.440-01	5.044-05	1.157+07
	68	3.2229	4142.5	1.0128	579.9	6114.5	1.391-01	5.033-05	1.149+07
32	69	3.2732	4233.0	1.0370	564.9	6092.6	1.344-01	5.021-05	1.138+07
	70	3.3237	4322.0	1.0610	549.3	6070.3	1.297-01	5.009-05	1.129+07
33	71	3.3741	4411.0	1.0851	533.8	6048.7	1.251-01	4.998-05	1.120+07
	72	3.4249	4499.0	1.1090	517.7	6026.8	1.205-01	4.986-05	1.087+07
34	73	3.4756	4587.0	1.1330	501.6	6005.4	1.161-01	4.975-05	1.078+07
	74	3.5265	4628.5	1.1457	485.0	5984.0	1.117-01	4.964-05	1.041+07
35	75	3.5774	4670.0	1.1583	468.4	5963.0	1.074-01	4.953-05	1.013+07
	76	3.6285	4800.5	1.1932	451.3	5942.0	1.032-01	4.942-05	1.008+07
36	77	3.6795	4931.0	1.2286	43[illegible]	5916.2	9.924-02	4.926-05	9.930+06
	78	3.7311	5015.5	1.2530	41[illegible]	5887.4	9.533-02	4.912-05	9.738+06
37	79	3.7826	5100.0	1.2775	399.1	5859.0	9.156-02	4.897-05	9.586+06
	80	3.8517	5227.7	1.3150	370.6	5814.6	8.674-02	4.873-05	9.198+06
	81	3.9207	5355.3	1.3527	342.2	5772.0	8.027-02	4.850-05	8.864+06
38	82	3.9898	5483.0	1.3905	313.8	5731.4	7.513-02	4.826-05	8.538+06
	83	4.0760	5586.3	1.4222	288.4	5696.3	7.076-02	4.809-05	8.228+06
	84	4.1622	5693.7	1.4540	262.9	5662.5	6.663-02	4.791-05	7.919+06
39	85	4.2484	5799.0	1.4859	237.5	5629.9	6.273-02	4.773-05	7.621+06
	86	4.3347	5901.0	1.5172	211.2	5597.4	5.890-02	4.756-05	7.308+06
	87	4.4211	6003.0	1.5491	184.9	5561.7	5.532-02	4.736-05	7.012+06
40	88	4.5074	6105.0	1.5819	158.6	5520.5	5.201-02	4.713-05	6.737+06
	89	4.5936	6187.0	1.6089	136.2	5484.1	4.932-02	4.693-05	6.502+06
	90	4.6798	6269.0	1.6360	113.8	5448.9	4.677-02	4.673-05	6.273+06
41	91	4.7660	6351.0	1.6632	91.4	5414.8	4.434-02	4.655-05	6.050+06

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	VELOCITY FT/SEC (UE)	MACH NO (HCAM)	ENTHALPY BTU/LBM (HE)	TEMPERATURE DEG R (TE)	DENSITY LBM/FT3 (ROE)	VISCOSITY LBM/FT-SEC (VISE)	UNIT RE NO 1/FT (URE
	92	4.8923	6430.7	1.6899	68.6	5381.2	4.196-02	4.636-05	5.621-06
	93	4.9385	6510.8	1.7167	45.8	5348.7	3.971-02	4.618-05	5.598-06
42	94	5.0248	6590.0	1.7436	23.0	5317.3	3.757-02	4.601-05	5.382-06
	95	5.1111	6651.7	1.7646	4.6	5292.5	3.590-02	4.587-05	5.206-06
	96	5.1974	6713.3	1.7850	-13.8	5271.5	3.428-02	4.575-05	5.038-06
43	97	5.2836	6775.0	1.8063	-32.3	5247.3	3.276-02	4.562-05	4.869-06
	98	5.3699	6835.0	1.8277	-50.8	5221.3	3.129-02	4.548-05	4.703-06
	99	5.4562	6895.0	1.8493	-69.4	5192.4	2.989-02	4.531-05	4.549-06
44	100	5.5425	6955.0	1.8711	-87.9	5163.1	2.856-02	4.515-05	4.401-06
	101	5.6287	7013.7	1.8927	-106.5	5133.0	2.727-02	4.497-05	4.252-06
	102	5.7150	7072.3	1.9143	-125.1	5103.5	2.603-02	4.480-05	4.108-06
45	103	5.8013	7131.0	1.9361	-143.7	5074.5	2.484-02	4.463-05	3.969-06
	104	5.8876	7173.7	1.9521	-157.6	5053.0	2.398-02	4.451-05	3.864-06
	105	5.9738	7216.3	1.9681	-171.6	5031.8	2.314-02	4.439-05	3.762-06
46	106	6.0601	7259.0	1.9842	-185.5	5010.9	2.234-02	4.427-05	3.668-06
	107	6.1464	7301.0	2.0004	-199.5	4989.7	2.155-02	4.415-05	3.564-06
47	108	6.2327	7343.0	2.0167	-213.4	4968.2	2.080-02	4.403-05	3.469-06
	109	6.3189	7385.0	2.0331	-227.3	4946.8	2.007-02	4.391-05	3.376-06
	110	6.4052	7439.3	2.0548	-245.8	4918.3	1.913-02	4.374-05	3.254-06
48	111	6.4915	7493.7	2.0766	-264.4	4889.9	1.824-02	4.358-05	3.136-06
	112	6.5778	7548.0	2.0987	-282.9	4861.5	1.739-02	4.342-05	3.023-06
	113	6.6640	7587.7	2.1146	-296.7	4840.4	1.676-02	4.330-05	2.938-06
49	114	6.7503	7627.3	2.1305	-310.5	4819.4	1.616-02	4.317-05	2.858-06
	115	6.8366	7667.0	2.1466	-324.3	4798.3	1.558-02	4.305-05	2.779-06
	116	6.9229	7706.0	2.1628	-338.0	4776.4	1.502-02	4.292-05	2.697-06
50	117	7.0091	7745.0	2.1794	-351.7	4753.4	1.449-02	4.279-05	2.622-06
	118	7.0954	7784.0	2.1960	-365.4	4730.7	1.397-02	4.265-05	2.549-06
	119	7.1817	7809.3	2.2069	-374.4	4715.8	1.363-02	4.256-05	2.501-06
51	120	7.2679	7834.7	2.2179	-383.5	4701.0	1.330-02	4.248-05	2.454-06
	121	7.3542	7860.0	2.2288	-392.6	4686.4	1.298-02	4.239-05	2.407-06
	122	7.4405	7897.3	2.2451	-406.1	4664.7	1.251-02	4.227-05	2.338-06
52	123	7.5268	7934.7	2.2614	-419.6	4643.3	1.206-02	4.214-05	2.271-06
	124	7.6130	7972.0	2.2777	-433.1	4622.2	1.162-02	4.202-05	2.209-06
	125	7.6993	8008.3	2.2938	-446.5	4601.5	1.120-02	4.190-05	2.148-06
53	126	7.7856	8044.7	2.3098	-459.8	4581.1	1.079-02	4.178-05	2.091-06
	127	7.8719	8081.0	2.3260	-473.2	4560.9	1.039-02	4.166-05	2.016-06
	128	7.9581	8105.0	2.3366	-482.8	4547.7	1.013-02	4.158-05	1.979-06
54	129	8.0444	8129.0	2.3473	-490.9	4534.6	9.881-03	4.150-05	1.939-06
	130	8.1307	8153.0	2.3581	-499.7	4521.2	9.637-03	4.143-05	1.897-06
	131	8.2170	8176.3	2.3694	-508.9	4505.9	9.403-03	4.134-05	1.864-06
55	132	8.3032	8199.7	2.3806	-517.2	4490.6	9.174-03	4.125-05	1.824-06
	133	8.3895	8223.0	2.3916	-526.0	4475.2	8.949-03	4.115-05	1.788-06
	134	8.4758	8246.0	2.4026	-534.7	4460.0	8.729-03	4.106-05	1.753-06
56	135	8.5621	8269.0	2.4137	-543.3	4444.9	8.515-03	4.097-05	1.719-06
	136	8.6483	8292.0	2.4248	-552.0	4429.7	8.306-03	4.088-05	1.685-06

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - WALL AND B. L. RECOVERY PROPERTIES

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	WALL TEMPERATURE DEG R (TW)	WALL ENTHALPY BTU/LBM (HW)	WALL DENSITY LBM/FT3 (ROW)	WALL VISCOSITY LBM/FT-SEC (VISW)	RECOVERY ENTHALPY BTU/LBM (HR)	RECOVERY FACTOR (RECOV)	SENSBL CONV HEAT FLUX BTU/FT2-SEC	CF/2
1	1	.0000	4939.0	-380.4	4.170-01	4.395-05	909.8	.6998	9.480+02	1.000+00
	2	.0481	4939.0	-380.3	4.160-01	4.395-05	908.9	.6998	9.464+02	2.719-02
	3	.0961	4939.0	-380.2	4.150-01	4.395-05	908.4	.6998	9.435+02	1.358-02
	4	.1442	4939.0	-380.2	4.140-01	4.395-05	908.0	.6998	8.812+02	1.116-02
	5	.1922	4939.0	-380.1	4.130-01	4.395-05	908.1	.7882	1.746+03	1.452-02
	6	.2403	4939.0	-380.1	4.120-01	4.395-05	908.4	.7882	1.713+03	1.055-02
2	7	.2884	4939.0	-380.0	4.110-01	4.395-05	908.9	.7882	1.750+03	8.589-03
	8	.3365	4939.0	-380.0	4.105-01	4.395-05	908.0	.7882	1.599+03	7.079-03
	9	.3845	4939.0	-379.9	4.099-01	4.395-05	908.8	.7882	1.558+03	6.611-03
3	10	.4101	4939.0	-379.9	4.094-01	4.395-05	908.7	.7882	1.544+03	6.862-03
	11	.4577	4939.0	-379.9	4.085-01	4.395-05	908.6	.7882	1.563+03	6.219-03
4	12	.5053	4939.0	-379.8	4.077-01	4.395-05	908.5	.7882	1.585+03	6.101-03
	13	.5463	4939.0	-379.7	4.067-01	4.395-05	908.3	.7882	1.620+03	6.045-03
5	14	.5873	4939.0	-379.7	4.057-01	4.395-05	908.2	.7882	1.656+03	5.994-03
	15	.6237	4939.0	-379.6	4.047-01	4.395-05	908.0	.7882	1.698+03	5.970-03
6	16	.6602	4939.0	-379.6	4.036-01	4.395-05	907.9	.7882	1.720+03	5.784-03
	17	.6938	4939.0	-379.5	4.031-01	4.395-05	907.8	.7882	1.700+03	5.524-03
7	18	.7274	4939.0	-379.5	4.025-01	4.395-05	907.7	.7882	1.721+03	5.560-03
	19	.7588	4939.0	-379.4	4.013-01	4.395-05	907.6	.7882	1.783+03	5.688-03
8	20	.7902	4939.0	-379.3	4.002-01	4.395-05	907.4	.7882	1.813+03	5.866-03
	21	.8202	4939.0	-379.3	3.995-01	4.395-05	907.3	.7882	1.800+03	5.358-03
9	22	.8501	4939.0	-379.3	3.989-01	4.395-05	907.2	.7882	1.806+03	5.178-03
	23	.8783	4939.0	-379.2	3.983-01	4.395-05	907.1	.7882	1.814+03	5.216-03
10	24	.9065	4939.0	-379.2	3.976-01	4.395-05	907.0	.7882	1.830+03	5.287-03
	25	.9613	4939.0	-379.1	3.956-01	4.395-05	906.7	.7882	1.901+03	5.259-03
11	26	1.0162	4939.0	-378.9	3.936-01	4.395-05	906.4	.7882	1.949+03	5.169-03
	27	1.0710	4939.0	-378.8	3.921-01	4.395-05	906.2	.7882	1.957+03	5.002-03
12	28	1.1258	4939.0	-378.7	3.907-01	4.395-05	906.0	.7882	1.983+03	4.969-03
	29	1.1800	4939.0	-378.6	3.883-01	4.395-05	905.6	.7882	2.042+03	4.988-03
13	30	1.2343	4939.0	-378.4	3.860-01	4.395-05	905.3	.7882	2.092+03	4.998-03
	31	1.2879	4939.0	-378.3	3.835-01	4.395-05	904.9	.7882	2.138+03	4.921-03
14	32	1.3416	4939.0	-378.1	3.810-01	4.395-05	904.5	.7882	2.182+03	4.886-03
	33	1.3948	4939.0	-377.9	3.784-01	4.395-05	904.0	.7882	2.225+03	4.858-03
15	34	1.4479	4939.0	-377.8	3.758-01	4.395-05	903.7	.7882	2.265+03	4.809-03
	35	1.5006	4939.0	-377.6	3.730-01	4.395-05	903.2	.7882	2.303+03	4.760-03
16	36	1.5532	4939.0	-377.4	3.702-01	4.395-05	902.8	.7882	2.345+03	4.765-03
	37	1.6058	4939.0	-377.1	3.663-01	4.395-05	902.0	.7882	2.410+03	4.799-03
17	38	1.6576	4939.0	-376.8	3.624-01	4.395-05	901.5	.7882	2.461+03	4.758-03
	39	1.7094	4939.0	-376.6	3.593-01	4.395-05	900.9	.7882	2.483+03	4.674-03
18	40	1.7612	4939.0	-376.4	3.562-01	4.395-05	900.4	.7882	2.514+03	4.695-03
	41	1.8127	4939.0	-376.1	3.519-01	4.395-05	899.6	.7882	2.563+03	4.663-03
19	42	1.8643	4939.0	-375.7	3.476-01	4.395-05	898.9	.7882	2.605+03	4.644-03
	43	1.9154	4939.0	-375.4	3.431-01	4.395-05	898.0	.7882	2.643+03	4.629-03
20	44	1.9664	4939.0	-375.0	3.386-01	4.395-05	897.3	.7882	2.677+03	4.597-03

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	WALL TEMPERATURE DEG R (TW)	WALL ENTHALPY BTU/LBM (HW)	WALL DENSITY LBM/FT3 (ROW)	WALL VISCOSITY LBM/FT-SEC (VISW)	RECOVERY ENTHALPY BTU/LBM (HR)	RECOVERY FACTOR (RECOV)	SENSBL CONV HEAT FLUX BTU/FT2-SEC	CF/2
	45	2.0178	4939.0	-374.7	3.339-01	4.395-05	896.3	.7882	2.705+03	4.567-03
21	46	2.0682	4939.0	-374.3	3.293-01	4.395-05	895.4	.7882	2.735+03	4.561-03
	47	2.1190	4939.0	-373.8	3.233-01	4.395-05	894.1	.7882	2.775+03	4.573-03
22	48	2.1697	4939.0	-373.3	3.173-01	4.395-05	893.0	.7882	2.809+03	4.548-03
	49	2.2202	4939.0	-372.9	3.124-01	4.395-05	891.9	.7882	2.812+03	4.482-03
23	50	2.2706	4939.0	-372.5	3.075-01	4.395-05	890.9	.7882	2.825+03	4.461-03
	51	2.3376	4939.0	-371.7	2.988-01	4.395-05	888.6	.7882	2.845+03	4.453-03
	52	2.4046	4939.0	-370.9	2.903-01	4.395-05	886.6	.7882	2.858+03	4.429-03
24	53	2.4716	4939.0	-370.0	2.821-01	4.395-05	885.0	.7882	2.865+03	4.388-03
	54	2.5217	4939.0	-369.4	2.756-01	4.394-05	883.3	.7882	2.860+03	4.360-03
25	55	2.5718	4939.0	-368.7	2.692-01	4.394-05	881.7	.7882	2.854+03	4.332-03
	56	2.6219	4939.0	-368.0	2.627-01	4.394-05	879.9	.7882	2.840+03	4.302-03
26	57	2.6719	4939.0	-367.3	2.563-01	4.394-05	878.2	.7882	2.834+03	4.315-03
	58	2.7219	4939.0	-366.1	2.458-01	4.394-05	874.9	.7882	2.818+03	4.351-03
27	59	2.7719	4939.0	-364.8	2.357-01	4.394-05	872.0	.7882	2.778+03	4.268-03
	60	2.8219	4939.0	-364.5	2.332-01	4.394-05	871.2	.7882	2.731+03	4.183-03
28	61	2.8719	4939.0	-364.1	2.306-01	4.394-05	870.4	.7882	2.719+03	4.109-03
	62	2.9219	4939.0	-363.1	2.230-01	4.394-05	867.6	.7882	2.690+03	4.128-03
29	63	2.9720	4939.0	-362.0	2.155-01	4.394-05	865.1	.7882	2.652+03	4.105-03
	64	3.0221	4939.0	-360.9	2.080-01	4.394-05	862.2	.7882	2.607+03	4.080-03
30	65	3.0722	4939.0	-359.8	2.008-01	4.394-05	859.5	.7882	2.561+03	4.053-03
	66	3.1224	4939.0	-358.6	1.934-01	4.394-05	856.4	.7882	2.508+03	4.024-03
31	67	3.1726	4939.0	-357.4	1.864-01	4.394-05	853.5	.7882	2.456+03	3.993-03
	68	3.2229	4939.0	-356.1	1.793-01	4.394-05	850.2	.7882	2.398+03	3.964-03
32	69	3.2732	4939.0	-354.7	1.725-01	4.394-05	847.1	.7882	2.340+03	3.933-03
	70	3.3237	4939.0	-353.3	1.657-01	4.394-05	843.6	.7882	2.277+03	3.900-03
33	71	3.3741	4939.0	-351.8	1.592-01	4.393-05	840.2	.7882	2.216+03	3.869-03
	72	3.4249	4939.0	-350.3	1.527-01	4.393-05	836.5	.7882	2.151+03	3.836-03
34	73	3.4756	4939.0	-348.8	1.465-01	4.393-05	833.0	.7882	2.082+03	3.775-03
	74	3.5265	4939.0	-347.3	1.403-01	4.393-05	822.4	.7882	1.973+03	3.683-03
35	75	3.5774	4939.0	-345.7	1.344-01	4.393-05	811.9	.7882	1.886+03	3.703-03
	76	3.6285	4939.0	-344.1	1.286-01	4.393-05	814.3	.7882	1.860+03	3.743-03
36	77	3.6795	4939.0	-342.5	1.230-01	4.393-05	817.2	.7882	1.825+03	3.705-03
	78	3.7311	4939.0	-340.5	1.175-01	4.393-05	812.9	.7882	1.753+03	3.641-03
37	79	3.7826	4939.0	-338.5	1.122-01	4.393-05	808.8	.7882	1.689+03	3.618-03
	80	3.8517	4939.0	-335.1	1.042-01	4.392-05	801.1	.7882	1.585+03	3.570-03
	81	3.9207	4939.0	-331.7	9.667-02	4.392-05	794.0	.7882	1.484+03	3.524-03
38	82	3.9898	4939.0	-328.3	8.973-02	4.392-05	787.4	.7882	1.388+03	3.458-03
	83	4.0760	4939.0	-325.3	8.388-02	4.392-05	780.3	.7882	1.300+03	3.378-03
	84	4.1622	4939.0	-322.2	7.842-02	4.392-05	773.5	.7882	1.220+03	3.328-03
39	85	4.2484	4939.0	-319.2	7.331-02	4.392-05	767.2	.7882	1.144+03	3.264-03
	86	4.3347	4939.0	-316.0	6.834-02	4.391-05	759.7	.7882	1.067+03	3.206-03
	87	4.4211	4939.0	-312.8	6.370-02	4.391-05	752.5	.7882	9.950+02	3.151-03
40	88	4.5074	4939.0	-309.3	5.937-02	4.391-05	745.7	.7882	9.269+02	3.085-03
	89	4.5936	4939.0	-305.6	5.588-02	4.391-05	739.2	.7882	8.692+02	3.022-03
	90	4.6798	4939.0	-301.9	5.256-02	4.391-05	732.8	.7882	8.157+02	2.970-03
41	91	4.7660	4939.0	-298.2	4.949-02	4.390-05	726.7	.7882	7.652+02	2.919-03

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	WALL TEMPERATURE DEG R (TW)	WALL ENTHALPY BTU/LBM (HW)	WALL DENSITY LBM/FT3 (ROW)	WALL VISCOSITY LBM/FT-SEC (VISW)	RECOVERY ENTHALPY BTU/LBM (HR)	RECOVERY FACTOR (RECOV)	SENSBL CONV HEAT FLUX BTU/FT2-SEC	CF/2
	92	4.8523	4939.0	-294.3	4.649-02	4.390-05	719.9	.7882	7.153+02	2.867-03
	93	4.9385	4939.0	-290.5	4.367-02	4.390-05	713.4	.7882	6.686+02	2.818-03
42	94	5.0248	4939.0	-286.7	4.103-02	4.390-05	707.1	.7882	6.243+02	2.768-03
	95	5.1111	4939.0	-283.6	3.898-02	4.390-05	701.5	.7882	5.893+02	2.708-03
	96	5.1974	4939.0	-280.5	3.704-02	4.389-05	696.1	.7882	5.567+02	2.668-03
43	97	5.2836	4939.0	-277.3	3.519-02	4.389-05	690.8	.7882	5.255+02	2.624-03
	98	5.3699	4939.0	-274.2	3.341-02	4.389-05	685.1	.7882	4.953+02	2.581-03
	99	5.4562	4939.0	-271.0	3.171-02	4.389-05	679.6	.7882	4.669+02	2.539-03
44	100	5.5425	4939.0	-267.6	3.010-02	4.389-05	674.2	.7882	4.399+02	2.496-03
	101	5.6287	4939.0	-261.9	2.855-02	4.388-05	668.4	.7882	4.124+02	2.452-03
	102	5.7150	4939.0	-256.3	2.707-02	4.388-05	662.8	.7882	3.866+02	2.409-03
45	103	5.8013	4939.0	-250.6	2.566-02	4.388-05	657.2	.7882	3.618+02	2.357-03
	104	5.8876	4939.0	-246.3	2.465-02	4.387-05	652.8	.7882	3.437+02	2.313-03
	105	5.9738	4939.0	-242.0	2.367-02	4.387-05	648.4	.7882	3.270+02	2.288-03
46	106	6.0601	4939.0	-237.7	2.273-02	4.387-05	644.2	.7882	3.110+02	2.246-03
	107	6.1464	4939.0	-233.3	2.182-02	4.387-05	639.8	.7882	2.955+02	2.213-03
	108	6.2327	4939.0	-229.0	2.095-02	4.386-05	635.5	.7882	2.807+02	2.179-03
47	109	6.3189	4939.0	-224.7	2.011-02	4.386-05	631.3	.7882	2.669+02	2.150-03
	110	6.4052	4939.0	-218.8	1.903-02	4.386-05	625.4	.7882	2.489+02	2.118-03
	111	6.4915	4939.0	-212.9	1.802-02	4.386-05	619.6	.7882	2.318+02	2.074-03
48	112	6.5778	4939.0	-207.1	1.705-02	4.385-05	613.9	.7882	2.155+02	2.021-03
	113	6.6640	4939.0	-202.6	1.635-02	4.385-05	609.5	.7882	2.037+02	1.979-03
	114	6.7503	4939.0	-198.2	1.569-02	4.385-05	605.2	.7882	1.929+02	1.945-03
49	115	6.8366	4939.0	-193.8	1.505-02	4.385-05	600.9	.7882	1.825+02	1.912-03
	116	6.9229	4939.0	-189.3	1.443-02	4.384-05	596.6	.7882	1.725+02	1.877-03
	117	7.0091	4939.0	-184.8	1.383-02	4.384-05	592.4	.7882	1.631+02	1.842-03
50	118	7.0954	4939.0	-180.4	1.326-02	4.384-05	588.2	.7882	1.539+02	1.797-03
	119	7.1817	4939.0	-177.4	1.290-02	4.384-05	585.3	.7882	1.479+02	1.763-03
	120	7.2679	4939.0	-174.4	1.254-02	4.383-05	582.5	.7882	1.423+02	1.739-03
51	121	7.3542	4939.0	-171.4	1.219-02	4.383-05	579.7	.7882	1.373+02	1.726-03
	122	7.4405	4939.0	-166.9	1.168-02	4.383-05	575.4	.7882	1.309+02	1.727-03
	123	7.5268	4939.0	-162.3	1.120-02	4.383-05	571.3	.7882	1.249+02	1.727-03
52	124	7.6130	4939.0	-157.8	1.073-02	4.383-05	567.1	.7882	1.192+02	1.727-03
	125	7.6993	4939.0	-153.3	1.028-02	4.382-05	562.9	.7882	1.137+02	1.727-03
	126	7.7856	4939.0	-148.7	9.854-03	4.382-05	558.7	.7882	1.085+02	1.728-03
53	127	7.8719	4939.0	-144.2	9.443-03	4.382-05	554.6	.7882	1.033+02	1.721-03
	128	7.9581	4939.0	-141.1	9.176-03	4.382-05	551.9	.7882	1.000+02	1.713-03
	129	8.0444	4939.0	-138.1	8.916-03	4.381-05	549.2	.7882	9.693+01	1.713-03
54	130	8.1307	4939.0	-135.0	8.664-03	4.381-05	546.5	.7882	9.391+01	1.718-03
	131	8.2170	4939.0	-132.0	8.419-03	4.381-05	543.8	.7882	9.095+01	1.712-03
	132	8.3032	4939.0	-128.9	8.181-03	4.381-05	541.1	.7882	8.809+01	1.711-03
55	133	8.3895	4939.0	-125.9	7.949-03	4.381-05	538.4	.7882	8.530+01	1.710-03
	134	8.4758	4939.0	-122.8	7.724-03	4.381-05	535.7	.7882	8.259+01	1.710-03
	135	8.5621	4939.0	-119.8	7.505-03	4.380-05	533.0	.7882	7.997+01	1.710-03
56	136	8.6483	4939.0	-116.7	7.292-03	4.380-05	530.4	.7882	7.742+01	1.709-03

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

VISCOUS FLOW - BOUNDARY LAYER SOLUTION

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	MOMENTUM THICKNESS MIL (THE)	ENERGY THICKNESS MIL (PHI)	SHAPE FACTOR (HSF)	MOM THICK RE NO (RETH)	ENERGY THICK RE NO (REPH)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCH)	REYNOLDS ANAL FAC (RAF)	INTER-MITTENCY (ADML)	HEAT TRANS AUGMENT (HUFSMT)
1	1	.0000	.281	.638	1.654	0.000	0.000	7.548-01	.9777	.00	1.000
	2	.0481	.281	.639	1.654	1.223+01	2.782+01	7.341-01	.9774	.00	1.000
	3	.0961	.281	.640	1.654	2.448+01	5.576+01	7.322-01	.9765	.00	1.000
	4	.1442	.310	.852	1.655	4.004+01	1.100+02	6.453-01	.7060	.00	1.000
	5	.1922	.517	1.101	1.332	8.882+01	1.891+02	1.355+00	.8574	1.00	1.546
	6	.2403	.691	1.387	1.173	1.479+02	2.969+02	1.330+00	.9291	1.00	1.542
2	7	.2884	.788	1.591	1.095	2.020+02	4.078+02	1.358+00	.9736	1.00	1.559
	8	.3269	.986	1.876	1.038	2.630+02	5.003+02	1.241+00	1.0377	1.00	1.518
	9	.3693	1.142	2.130	1.003	3.163+02	5.900+02	1.209+00	1.0424	1.00	1.507
3	10	.4101	1.271	2.369	.979	3.653+02	6.806+02	1.198+00	1.0349	1.00	1.504
	11	.4577	1.367	2.605	.959	4.138+02	7.886+02	1.213+00	1.0174	1.00	1.511
4	12	.5053	1.448	2.833	.944	4.605+02	9.010+02	1.231+00	1.0014	1.00	1.518
	13	.5463	1.491	3.003	.933	4.969+02	1.001+03	1.258+00	.9868	1.00	1.529
5	14	.5875	1.533	3.171	.924	5.340+02	1.104+03	1.286+00	.9728	1.00	1.539
	15	.6287	1.854	3.308	.917	5.646+02	1.199+03	1.319+00	.9605	1.00	1.550
6	16	.6602	1.588	3.429	.910	6.006+02	1.297+03	1.336+00	.9649	1.00	1.556
	17	.6938	1.684	3.597	.901	6.496+02	1.387+03	1.321+00	.9795	1.00	1.549
7	18	.7274	1.769	3.764	.894	6.955+02	1.480+03	1.337+00	.9654	1.00	1.551
	19	.7588	1.757	3.844	.891	7.163+02	1.567+03	1.386+00	.9444	1.00	1.566
8	20	.7902	1.755	3.926	.888	7.410+02	1.656+03	1.409+00	.9475	1.00	1.573
	21	.8202	1.825	4.060	.882	7.839+02	1.744+03	1.399+00	.9613	1.00	1.568
9	22	.8501	1.898	4.193	.877	8.290+02	1.831+03	1.404+00	.9628	1.00	1.567
	23	.8783	1.957	4.306	.872	8.684+02	1.911+03	1.410+00	.9634	1.00	1.567
10	24	.9065	2.009	4.419	.869	9.058+02	1.992+03	1.423+00	.9585	1.00	1.569
	25	.9613	2.021	4.559	.865	9.542+02	2.153+03	1.479+00	.9420	1.00	1.583
11	26	1.0162	2.044	4.704	.861	1.008+03	2.320+03	1.517+00	.9419	1.00	1.592
	27	1.0710	2.147	4.917	.855	1.089+03	2.493+03	1.523+00	.9503	1.00	1.590
12	28	1.1256	2.242	5.129	.850	1.168+03	2.671+03	1.544+00	.9452	1.00	1.592
	29	1.1800	2.258	5.272	.848	1.221+03	2.851+03	1.590+00	.9344	1.00	1.602
13	30	1.2343	2.276	5.421	.845	1.276+03	3.039+03	1.629+00	.9292	1.00	1.610
	31	1.2879	2.301	5.570	.843	1.334+03	3.229+03	1.666+00	.9253	1.00	1.617
14	32	1.3416	2.332	5.722	.841	1.396+03	3.426+03	1.701+00	.9220	1.00	1.623
	33	1.3948	2.364	5.871	.839	1.459+03	3.625+03	1.735+00	.9192	1.00	1.629
15	34	1.4479	2.401	6.023	.837	1.526+03	3.830+03	1.768+00	.9173	1.00	1.634
	35	1.5006	2.440	6.174	.836	1.595+03	4.035+03	1.798+00	.9159	1.00	1.638
16	36	1.5532	2.475	6.330	.835	1.661+03	4.248+03	1.832+00	.9099	1.00	1.644
	37	1.6054	2.455	6.433	.835	1.702+03	4.461+03	1.884+00	.9006	1.00	1.654
17	38	1.6576	2.450	6.544	.835	1.753+03	4.683+03	1.925+00	.9000	1.00	1.661
	39	1.7094	2.505	6.702	.834	1.852+03	4.903+03	1.943+00	.9042	1.00	1.662
18	40	1.7612	2.559	6.863	.833	1.912+03	5.127+03	1.969+00	.9011	1.00	1.664
	41	1.8127	2.564	6.962	.833	1.966+03	5.354+03	2.009+00	.8951	1.00	1.671
19	42	1.8643	2.572	7.108	.834	2.022+03	5.588+03	2.044+00	.8923	1.00	1.676
	43	1.9154	2.584	7.251	.835	2.078+03	5.816+03	2.075+00	.8901	1.00	1.681
20	44	1.9664	2.603	7.360	.835	2.139+03	6.050+03	2.104+00	.8888	1.00	1.684

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	MOMENTUM THICKNESS MIL (THE)	ENERGY THICKNESS MIL (PHI)	SHAPE FACTOR (HSF)	MOM THICK RE NO (RETH)	ENERGY THICK RE NO (REPH)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCH)	REYNOLDS ANAL FAC (RAF)	INTERMITTENCY (ADML)	HEAT TRANS AUGMENT (HOFSMT)
	45	2.0173	2.629	7.495	.836	2.203+03	6.282+03	2.128+00	.8880	1.00	1.687
21	46	2.0682	2.653	7.635	.837	2.266+03	6.520+03	2.154+00	.8842	1.00	1.690
	47	2.1190	2.643	7.748	.839	2.305+03	6.758+03	2.189+00	.8783	1.00	1.696
22	48	2.1697	2.644	7.869	.841	2.352+03	7.001+03	2.214+00	.8783	1.00	1.700
	49	2.2202	2.688	8.021	.842	2.425+03	7.235+03	2.223+00	.8816	1.00	1.699
23	50	2.2706	2.734	8.176	.843	2.499+03	7.472+03	2.236+00	.8802	1.00	1.700
	51	2.3376	2.751	8.356	.846	2.560+03	7.777+03	2.258+00	.8757	1.00	1.702
	52	2.4046	2.774	8.547	.850	2.625+03	8.087+03	2.272+00	.8741	1.00	1.704
24	53	2.4716	2.809	8.748	.853	2.697+03	8.401+03	2.283+00	.8734	1.00	1.705
	54	2.5217	2.840	8.905	.856	2.749+03	8.621+03	2.283+00	.8732	1.00	1.704
25	55	2.5718	2.873	9.067	.858	2.802+03	8.843+03	2.282+00	.8732	1.00	1.703
	56	2.6219	2.911	9.235	.861	2.854+03	9.055+03	2.276+00	.8734	1.00	1.701
26	57	2.6719	2.937	9.408	.864	2.894+03	9.268+03	2.275+00	.8673	1.00	1.701
	58	2.7219	2.904	9.590	.871	2.871+03	9.480+03	2.270+00	.8572	1.00	1.703
27	59	2.7719	2.897	9.779	.878	2.873+03	9.699+03	2.246+00	.8636	1.00	1.701
	60	2.8219	3.019	9.956	.879	2.994+03	9.877+03	2.210+00	.8848	1.00	1.691
28	61	2.8719	3.141	10.133	.879	3.117+03	1.005+04	2.203+00	.8810	1.00	1.686
	62	2.9219	3.178	10.332	.885	3.148+03	1.024+04	2.166+00	.8735	1.00	1.684
29	63	2.9720	3.203	10.538	.891	3.165+03	1.042+04	2.161+00	.8723	1.00	1.681
	64	3.0221	3.233	10.756	.897	3.181+03	1.058+04	2.131+00	.8714	1.00	1.677
30	65	3.0722	3.267	10.980	.903	3.198+03	1.075+04	2.100+00	.8708	1.00	1.673
	66	3.1214	3.307	11.214	.909	3.213+03	1.090+04	2.065+00	.8705	1.00	1.668
31	67	3.1725	3.349	11.455	.915	3.228+03	1.104+04	2.028+00	.8702	1.00	1.662
	68	3.2229	3.396	11.710	.922	3.240+03	1.117+04	1.988+00	.8702	1.00	1.656
32	69	3.2732	3.445	11.971	.923	3.253+03	1.130+04	1.947+00	.8703	1.00	1.650
	70	3.3237	3.499	12.244	.935	3.261+03	1.141+04	1.903+00	.8706	1.00	1.643
33	71	3.3741	3.553	12.523	.942	3.269+03	1.152+04	1.859+00	.8709	1.00	1.636
	72	3.4249	3.611	12.813	.949	3.272+03	1.161+04	1.812+00	.8712	1.00	1.629
34	73	3.4756	3.670	13.109	.956	3.273+03	1.169+04	1.762+00	.8768	1.00	1.620
	74	3.5265	3.801	13.554	.962	3.299+03	1.176+04	1.687+00	.8860	1.00	1.606
35	75	3.5774	3.930	14.010	.969	3.318+03	1.183+04	1.629+00	.8767	1.00	1.596
	76	3.6285	3.918	14.215	.976	3.274+03	1.188+04	1.606+00	.8658	1.00	1.594
36	77	3.6795	3.914	14.422	.985	3.238+03	1.193+04	1.573+00	.8679	1.00	1.589
	78	3.7311	3.983	14.765	.995	3.230+03	1.198+04	1.520+00	.8732	1.00	1.579
37	79	3.7826	4.048	15.118	1.004	3.217+03	1.201+04	1.472+00	.8726	1.00	1.570
	80	3.8517	4.147	15.736	1.020	3.179+03	1.206+04	1.393+00	.8708	1.00	1.555
	81	3.9207	4.244	16.385	1.035	3.155+03	1.210+04	1.318+00	.8701	1.00	1.540
38	82	3.9898	4.355	17.066	1.049	3.097+03	1.213+04	1.244+00	.8733	1.00	1.524
	83	4.0760	4.511	17.720	1.062	3.091+03	1.214+04	1.176+00	.8805	1.00	1.507
	84	4.1622	4.681	18.401	1.074	3.089+03	1.214+04	1.113+00	.8837	1.00	1.491
39	85	4.2484	4.851	19.112	1.086	3.081+03	1.214+04	1.053+00	.8869	1.00	1.475
	86	4.3347	5.036	19.909	1.098	3.067+03	1.212+04	9.917-01	.8900	1.00	1.458
	87	4.4211	5.217	20.729	1.111	3.048+03	1.211+04	9.339-01	.8925	1.00	1.441
40	88	4.5074	5.399	21.571	1.127	3.031+03	1.211+04	8.786-01	.8970	1.00	1.424
	89	4.5936	5.581	22.342	1.141	3.024+03	1.211+04	8.320-01	.9021	1.00	1.409
	90	4.6798	5.768	23.142	1.155	3.015+03	1.210+04	7.883-01	.9052	1.00	1.394
41	91	4.7660	5.955	23.974	1.166	3.002+03	1.209+04	7.467-01	.9084	1.00	1.379

MOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	MOMENTUM THICKNESS MIL (THE)	ENERGY THICKNESS MIL (PHI)	SHAPE FACTOR (HSF)	MOM THICK RE NO (RETH)	ENERGY THICK RE NO (REPH)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (HUCH)	REYNOLDS ANAL FAC (RAF)	INTER-MITTENCY (ADML)	HEAT TRANS AUGMENT (RUFSAT)
	92	4.8528	6.153	24.885	1.182	2.985+03	1.207+04	7.053-01	.9116	1.00	1.363
	93	4.9385	6.351	25.832	1.195	2.963+03	1.205+04	6.660-01	.9144	1.00	1.348
42	94	5.0248	6.557	26.820	1.208	2.940+03	1.203+04	6.282-01	.9194	1.00	1.332
	95	5.1111	6.745	27.630	1.219	2.926+03	1.199+04	5.982-01	.9250	1.00	1.318
	96	5.1974	6.945	28.490	1.228	2.911+03	1.194+04	5.700-01	.9264	1.00	1.305
43	97	5.2836	7.139	29.352	1.238	2.894+03	1.190+04	5.428-01	.9319	1.00	1.292
	98	5.3699	7.338	30.263	1.249	2.876+03	1.186+04	5.164-01	.9355	1.00	1.278
	99	5.4562	7.536	31.199	1.262	2.857+03	1.183+04	4.912-01	.9387	1.00	1.265
44	100	5.5425	7.732	32.168	1.275	2.835+03	1.180+04	4.671-01	.9421	1.00	1.252
	101	5.6287	7.938	33.272	1.288	2.813+03	1.179+04	4.433-01	.9453	1.00	1.238
	102	5.7150	8.144	34.416	1.302	2.788+03	1.178+04	4.206-01	.9485	1.00	1.224
45	103	5.8013	8.358	35.601	1.315	2.764+03	1.177+04	3.985-01	.9545	1.00	1.210
	104	5.8876	8.532	36.460	1.325	2.748+03	1.174+04	3.823-01	.9608	1.00	1.198
	105	5.9738	8.714	37.343	1.335	2.732+03	1.171+04	3.672-01	.9644	1.00	1.187
46	106	6.0601	8.895	38.250	1.345	2.715+03	1.167+04	3.526-01	.9681	1.00	1.177
	107	6.1464	9.080	39.200	1.355	2.697+03	1.164+04	3.384-01	.9719	1.00	1.166
	108	6.2327	9.264	40.170	1.365	2.678+03	1.161+04	3.247-01	.9756	1.00	1.155
47	109	6.3189	9.439	41.166	1.376	2.656+03	1.158+04	3.118-01	.9765	1.00	1.144
	110	6.4052	9.681	42.703	1.390	2.625+03	1.158+04	2.948-01	.9781	1.00	1.130
	111	6.4915	9.915	44.296	1.405	2.591+03	1.158+04	2.784-01	.9820	1.00	1.115
48	112	6.5778	10.158	45.948	1.419	2.559+03	1.157+04	2.624-01	.9893	1.00	1.099
	113	6.6640	10.346	47.164	1.430	2.533+03	1.155+04	2.508-01	.9966	1.00	1.087
	114	6.7503	10.545	48.417	1.441	2.509+03	1.152+04	2.400-01	1.0009	1.00	1.075
49	115	6.8366	10.743	49.705	1.452	2.484+03	1.149+04	2.296-01	1.0055	1.00	1.063
	116	6.9229	10.944	51.040	1.464	2.460+03	1.147+04	2.195-01	1.0103	1.00	1.051
	117	7.0091	11.148	52.401	1.476	2.435+03	1.145+04	2.098-01	1.0151	1.00	1.040
50	118	7.0954	11.351	53.803	1.488	2.411+03	1.143+04	2.002-01	1.0244	1.00	1.027
	119	7.1817	11.484	54.607	1.497	2.393+03	1.138+04	1.939-01	1.0331	1.00	1.018
	120	7.2679	11.628	55.430	1.505	2.377+03	1.133+04	1.881-01	1.0376	1.00	1.009
51	121	7.3542	11.761	56.270	1.513	2.359+03	1.129+04	1.827-01	1.0379	1.00	1.002
	122	7.4405	11.986	57.845	1.525	2.335+03	1.127+04	1.763-01	1.0335	1.00	1.000
	123	7.5268	12.204	59.472	1.537	2.309+03	1.125+04	1.703-01	1.0306	1.00	1.000
52	124	7.6130	12.426	61.152	1.549	2.283+03	1.124+04	1.645-01	1.0280	1.00	1.000
	125	7.6993	12.659	62.913	1.562	2.258+03	1.122+04	1.588-01	1.0253	1.00	1.000
	126	7.7856	12.897	64.734	1.574	2.232+03	1.120+04	1.533-01	1.0224	1.00	1.000
53	127	7.8719	13.150	66.615	1.585	2.209+03	1.119+04	1.479-01	1.0234	1.00	1.000
	128	7.9581	13.309	67.726	1.593	2.191+03	1.115+04	1.443-01	1.0261	1.00	1.000
	129	8.0444	13.482	68.863	1.601	2.174+03	1.111+04	1.410-01	1.0249	1.00	1.000
54	130	8.1307	13.656	70.020	1.609	2.156+03	1.107+04	1.378-01	1.0238	1.00	1.000
	131	8.2170	13.828	71.175	1.619	2.143+03	1.103+04	1.346-01	1.0228	1.00	1.000
	132	8.3032	14.004	72.366	1.628	2.128+03	1.100+04	1.315-01	1.0215	1.00	1.000
55	133	8.3895	14.183	73.589	1.637	2.114+03	1.097+04	1.284-01	1.0203	1.00	1.000
	134	8.4758	14.367	74.848	1.647	2.099+03	1.093+04	1.254-01	1.0191	1.00	1.000
	135	8.5621	14.553	76.133	1.656	2.084+03	1.090+04	1.225-01	1.0177	1.00	1.000
56	136	8.6483	14.740	77.446	1.666	2.070+03	1.087+04	1.196-01	1.0168	1.00	1.000

Section 6. Program Listing

A listing of the Fortran source deck is given in this section. The common block and block data are presented first, the driver routine which is the main program is given next, followed by all the subroutines in the program.

COMBLK

```
PE    1          COMON# PROC
      2                COMMON  /CONST/
      3               # ALMAX, ALMIN, DEXMIN,DLTMIN,DLTRAN,DSHANG,HJNCTN,HZEROT,IATM,
      4               # IBRUPT,ICARB, IFL609,IHMAX, IL,    IPMAX, IPRFLG,IPRNT, IRON,
      5               # IRSTRT,ISHFLG,ISS,   JL,    LG,    LL,    MATN,  NAR,   NCL,
      6               # NOHEAL,NOSLO, NPRTBL,NREYCR,NSHTBL,NTFIX, NTIMT, NTMUSR,OX,
      7               # OY,    PR,    RNI,   RSIDE, SPHTC, STRD,  THETA, TRNTIM,ZMAX,
      8               # ZSIDE1,ZSTAG1,
      9               # AGLAW(3),  ALCL(50),  ALT(60),   AM(60),    BGLAW(3),  BLH(3),
     10               # BLS(3),    BTH(3),    BTS(3),    CGLAW(3),  CHOSTT(60),CMH(3),
     11               # CZI(50),   DEL(15),   DGLAW(3),  DM(150,25),DPI(50),   EGLAW(3),
     12               # EMT(35,21),ET(35,21), FE[illegible](35),  FLPT(21),FLTT(35,21),
     13               # GT(35,21), HFO(3)     [illegible]HT(35),   JROUGH(3),KHI(5,5,3),
     14               # NERODE(3), [illegible],NLO(5,5,3),NMAT(50,25),NMG(3),   NPR(3),
     15               # PA(60),    [illegible]0), PSTT(60),  PT(21),    RECORD(86),REM(30),
     16               # RHO(3),    RUFL(3),   RUFMAX(3), RUFI(3),   SGI(50),   TA(60),
     17               # TBFP(1950),TCHEM(1950),TCP(30,3),TEMT(35,21),TEP(30,3),TFO(3),
     18               # TMZ(60,3), TIMT(60),  TIMUSR(250),TKP(60,3),TLMC(1950),TMG(5,3),
     19               # TPR(5,3),  TPSTR(60), TTP(60,3), TTS(1950), VEL(60),   X(50),
     20               # XDIF(60),  XINIT(50), XPNTBL(60),Y(25),     YDIF([illegible]5), YINIT(50)
     21                COMMON  /ENVR/
     22               # ALTINF,AMACH, A1,    A2,    CDRAG, DEN,   DUDZ,  EMWT2, EMW2,
     23               # E2,    GAM1,  GAM2,  METAUG,MT2,   M1,    M2,    [illegible]XX,  INOSE,
     24               # KSHOLD,LCT,   LTT,   NOSTRN,NPGENV,NT,    NTS,   [illegible]   PT2,
     25               # P1,    P2,    REYCR, RN,    ROT2,  RO1,   RO2,   SP[illegible]IC,STRAN,
     26               # TSTAGP,TT2,   T1,    T2,   UR1,  VIST2, VIS2,  V1,    V2,
     27               # ADNL(150), ALTEND(250),BETA(150),BETP(150), BP(150), [illegible]DRGED(250),
     28               # CSEE(150), DRDS(150), ENTR(150), HCAM(150), HE(150),   HR(150),
     29               # HSF(150),  HW(150),   IPT(150),  MATL(150), PE(150),   PEPI(150),
     30               # PHI(150),  R(150),    RAF(150),  REPH(150), RETH(150), ROE(150),
     31               # ROUE(150), ROW(150),  RUCH(150), RUF(150),  RUFSMT(150),S(150),
     32               # SOR(150),  SRB(150),  TE(150),   THE(150),THETB(150),TIMEND(250),
     33               # TP(150),   TUE(150),  TW(150),   UE(150),   URE(150),  VISE(150),
     34               # VISW(150), XSHC(150), YBAR(150), YSHC(150), Z(150),   ZSIDED(250),
     35               # ZSPEND(250)
     36                COMMON  /RECS/
     37               # CZ,    DPART1,DTH,   IUSER, MT,    MTNU,  NPG,   NS,    S6,
     38               # TIMENU,TIMEP, TS,    VR,
     39               # BLEN(60,2),BPSP(60),  CHOX(60),  CMFX(60),  DELKE(60), DFIF(60),
     40               # DPART(60), EFFK(60),  EMDOT(60), FI(60),    FVW(60),   GKR(60),
     41               # HRSP(60),  IHI(38),   ILO(38),   IMAT(60,15),IR(38),    NB(60,3),
     42               # PRESP(60), RI(60,2),  RSP(60),   RSPNU(60), RUCHSP(60),SDOT(60),
     43               # SDOTE(60), SP(60),    SRAY(60),  TANFI(60), THETSP(60),TSP(60),
     44               # VIMP(60),  ZI(60,2),  ZSP(60),   ZSPNU(60)
     45                COMMON  /COND/
     46               # ANGLE, DLTC,  DLTL,  DLTS,  FIKLN, KEND,  KL,    KLF,   KMAX,
     47               # KSTART,NOUT,  QDOTMN,QDOTMO,STRM,  TERMA, TERMB, TERMC,
     48               # DELTAA(60),DOR(60),   NREG(50,25),QW(60),   T(50,25),  TIW1(60),
     49               # TT(60,15), XS(60,15), YS(60,15)
     50           END
PE   51          COMUNT# PROC
     52                COMMON  / UNITS /
     53               # ATM,   BTU,   BTUCAL,CMFT,  DEGFR, DEGRK,  DENH2O,EINMIC,EL8FT3,
     54               # EMETER,EMICMR,EMMFT, FT,    FTMIL, FT2,   GC,    PI,    PI02,
     55               # RAD,   RU,    SIG,   STDTEM
```

```
00101     1.        BLOCK DATA
00101     2.  C
00101     3.  C-------------------------------- ------------------------------
00101     4.  C
00101     5.  C     THIS ROUTINE CONTAINS ALL THE TABLES PRODUCED BY ACE FOR
00101     6.  C     THE ESTATE ROUTINE
00101     7.  C
00101     8.  C-------------------------------- ------------------------------
00101     9.  C
00102    10.        INCLUDE COMON
00107    11.        INCLUDE COMUNT
00107    12.  C                                      FOR VALUES OF M LESS THAN MJNCTN,
00107    13.  C                                          C IS PROPORTIONAL TO LN(M)
00107    14.  C                                      FOR VALUES OF M GREATER THAN MJNCTN,
00107    15.  C                                          E IS PROPORTIONAL TO M.
00107    16.  C                                      (SEE ESTATE SUBROUTINE)
00111    17.        DATA PI     / 3.14159265 /,
00111    18.       *     PIO2   / 1.57079633 /,
00111    19.  C                                      PI/2.
00111    20.       *     FT     / 12.        /,
00111    21.  C                                      INCHES/FT
00111    22.       *     FT2    / 144.       /,
00111    23.  C                                      INCH2/FT2
00111    24.       *     RAD    / 57.2957795 /,
00111    25.  C                                      DEGREES/RADIAN
00111    26.       *     ATM    / 14.6959    /,
00111    27.  C                                      PSI/ATM
00111    28.       *     GC     / 32.1740    /,
00111    29.  C                                      LBM-FT/LBF-SEC2
00111    30.       *     BTU    / 778.158    /,
```

```
00111     81*     C
                                                        FT=LOF/BTU
00111     82*          *     FTMIL  / 12000.     /,
00111     83*     C
                                                        MIL/FT
00111     84*          *     EMETER / 3.280839   /,
00111     85*     C
                                                        FT/METER
00111     86*          *     STDTEM / 530.       /,
00111     87*     C
                                                        STANDARD TEMPERATURE
00111     88*          *     DEGFR  / 459.7      /,
00111     89*     C
                                                        DEG R = DEG F + DEGFR
00111     90*          *     RU     / .73063     /,
00111     91*     C
                                                        UNIVERSAL GAS CONSTANT,
00111     92*     C                                      (ATM)-(LBM/MOLE)/(LBM/FT3)-(DEG R)
00111     93*          *     SIG    /4.75502E-13 /
00111     94*     C
                                                        STEFAN-BOLTZMANN CONSTANT,
00111     95*     C                                      BTU/FT2-DEG R4-SEC
00130     96*           DATA ELBFT3 / 62.4280E-6 /,
00130     97*     C
                                                        (LBM/FT3)/(GM/M3)
00130     98*          *     BTUCAL / 251.996    /,
00130     99*     C
                                                        CAL/BTU
00130    100*          *     DENH2O / 62.4280    /,
00130    101*     C
                                                        DENSITY OF WATER
00130    102*          *     DEGRK  / 1.8        /,
00130    103*     C
                                                        DEG R/DEG K
00130    104*          *     FMMFT  /3.280839E-3 /,
00130    105*     C
                                                        FT/MM
00130    106*          *     FMICMM / .001       /,
00130    107*     C
                                                        MM/MICRON
00130    108*          *     FINMIC / 39.3701E-6 /,
00130    109*     C
                                                        INCH/MICRON
00130    110*          *     CMFT   / .03280839  /
00130    111*     C
                                                        FT/CM
00141    112*           END
```

```
00101    1*        INCLUDE COMON                                                  000001
00107    2*        COMMON/RUFF/IROUGH,RUF2(150)                                   000001
00110    3*        COMMON/TABLE/LT8                                               000001
00111    4*        DIMENSION STOR(35,21)                                          000001
00112    5*        CZ=0.                                                          000001
00113    6*        DPART1=0.                                                      000001
00114    7*        READ(5,99) NSM,IROUGH,CMH(1),GAM2,S(1),RN                      000002
00124    8*   99   FORMAT(2I1,F8.5,3F10.5)                                        000003
00125    9*        IF(CMH(1).LT..00001) CMH(1)=1.                                 000022
00127   10*        IF(GAM2.LT..00001) GAM2=1.2                                    000022
00131   11*        CALL LCOUNT(-54)                                               000030
00132   12*        WRITE(6,101) NSM,CMH(1),GAM2                                   000036
00137   13*   101  FORMAT(///,T10,22HNUMBER OF MATERIALS = ,I3/T10,8HCM/CH = ,F10.5,  000041
     *,/T10,22HISENTROPIC EXPONENT = ,F10.5)                                     000051
00137   14*        IF(ABS(RN).GT..00001) WRITE(6,1011)RN                          000051
03140   15*        IF(ABS(RN).LT..00001) RN=1.0                                   000051
00144   16*   1011 FORMAT(T10,76HTHE INITIAL SOLUTION IS THE STAGNATION SOLUTION OF A  000071
     * SPHERE WITH A RADIUS OF,F8.3,6HINCHES)                                     000071
00144   17*        DO 102 I=1,NSM                                                 000071
00145   18*        IF(IROUGH.EQ.1) READ(5,170) BTS(I),BTH(I),BLS(I),BLH(I)        000102
00147   19*   102  IF(IROUGH.EQ.0) READ(5,103) BTS(I),BTH(I),BLS(I),BLH(I),RUFL(I),  000102
     *RUFMAX(I),RUF1(I)                                                         000114
00152   20*        IF(IROUGH.EQ.1) GO TO 600                                      000114
00161   21*        DO 601 I=1,NSM                                                 000134
00161   22*        RUFL(I)=RUFL(I)/12000.                                         000142
00174   23*        RUFMAX(I)=RUFMAX(I)/12000.                                     000142
00176   24*   601  RUF1(I)=RUF1(I)/12000.                                         000146
00201   25*   600  CONTINUE                                                       000147
00202   26*   170  FORMAT(4F10.5)                                                 000154
00203   27*   103  FORMAT(7F10.5)                                                 000154
00205   28*        DO 104 I=1,NSM                                                 000154
00206   29*        IF(ABS(BTS(I)).LT..00001) BTS(I)=0.35                          000154
00207   30*        IF(ABS(BTH(I)).LT..00001) BTH(I)=.35                           000161
00210   31*        IF(ABS(BLS(I)).LT..00001) BLS(I)=0.5                           000166
00213   32*   104  IF(ABS(BLH(I)).LT..00001) BLH(I)=0.5                          000174
00215   33*        WRITE(6,106)                                                   000202
00217   34*   106  FORMAT(////T10,4HMATL,T27,3HBTS,T44,3HBTH,T59,3HBLS,T75,3HBLH/)  000212
00221   35*        WRITE(6,105) (I,BTS(I),BTH(I),BLS(I),BLH(I),I=1,NSM)           000217
00224   36*   105  FORMAT(T11,I2,T23,F10.5,T39,F10.5,T55,F10.5,T71,F10.5)        000217
00226   37*        READ(5,120) NS,IBRUPT,NREYCR,IPRNT,DLTRAN,ICARB,JROUGH(1)      000237
00227   38*   120  FORMAT(4I2,F10.5,2I2)                                          000237
00241   39*        WRITE(6,50) NS,IBRUPT,NREYCR,IPRNT,DLTRAN                      000253
00242   40*   50   FORMAT(////T10,5HNS = ,I2/T10,9HIBRUPT = ,I2/T10,9HNREYCR = ,I2/  000253
     *T10,8HIPRNT = ,I2/T10,9HDLTRAN = ,F10.5,8H  INCHES/)                       000265
00253   41*        DLTRAN=DLTRAN/12.                                              000265
00255   42*   130  IF(IABS(JROUGH(1)).NE.1) GO TO 131                            000265
00257   43*        WRITE(6,1130)                                                  000270
00261   44*   1130 FORMAT(//T10,53HTRANSITION PROXIMITY AUGMENTATION TO LAMINAR HEATI  000278
     *NG )                                                                      000301
00261   45*   131  CONTINUE                                                       000301
00262   46*        IF(IBRUPT.EQ.0) WRITE(6,1120)                                  000301
00263   47*   1120 FORMAT(//T10,20HTRANSITIONAL HEATING)                          000301
00267   48*        IF(IBRUPT.EQ.1) WRITE(6,2120)                                  000307
00271   49*   2120 FORMAT(//T10,17HABRUPT TRANSITION)                             000307
00271   50*        IF(IABS(NREYCR).EQ.0)   NREYCR=7                               000317
00272   51*        IF(IABS(NREYCR).EQ.2)      GO TO 122                           000317
00273   52*        IF(IABS(NREYCR).EQ.3)      GO TO 122                           000320
00276   53*                                                                       000327
00277   54*
00302   55*
00303   56*
00305   57*
00307
```

```
00311    98*          IF(NREYCR.EQ.1) WRITE(6,144)                                          000332
00314    99*     144  FORMAT(//T10,19HFLOW IS LAMINAR)                                      000342
00315    60*          IF(NREYCR.EQ.4) WRITE(6,151) DLTRAN                                   000342
00321    61*     151  FORMAT(//T10,28HTRANSITION OCCURS AT,F10.4,7H INCHES)                 000353
00322    62*          IF(NREYCR.EQ.5) WRITE(6,121)                                          000353
00325    63*     121  FORMAT(//T10,58HTRANSITION DETERMINED BY ANDERSON NOSE CRITERION(N    000363
                     *REYCR=5))                                                            000363
00326    65*          IF(NREYCR.EQ.6) WRITE(6,152) ICARB                                    000363
00332    66*     152  FORMAT(//T10,66HTRANSITION DETERMINED BY ANDERSON NOSE CRITERION (    000374
00332    67*          *NREYCR=6),ICARB=,I2,1H))                                             000374
00333    68*          IF(NREYCR.EQ.7) WRITE(6,1152)                                         000374
00336    69*     1152 FORMAT(//T10,17HFLOW IS TURBULENT)                                    000404
00337    70*          GO TO 145                                                             000404
00340    71*     122  READ(5,120) NAM                                                      000406
00343    72*          READ(5,2) (REM(I),I=1,NAM)                                            000413
00351    73*          READ(5,2) (AM(I),I=1,NAM)                                             000430
00357    74*          IF(IABS(NREYCR).EQ.2) GO TO 127                                       000442
00361    75*          WRITE(6,128)                                                          000445
00363    76*     129  FORMAT(//T10,49HTRANSITION DETERMINED BY CRITICAL MOMENTUM THICKN.    000452
00363    77*          *34HESS REYNOLDS NO. VS. EDGE MACH NO.,                               000452
00363    78*          *      /T24,22HCRITICAL STREAM LENGTH,T64,11HMACH NUMBER,/T29,        000452
00363    79*          *19HREYNOLDS NUMBER,/)                                                000452
00364    80*     128  FORMAT(//T10,47HTRANSITION DETERMINED BY CRITICAL STREAM LENGTH,      000452
00364    81*          *40HREYNOLDS NO. VS. EDGE MACH NO.,                                   000452
00364    82*          *      /T24,22HCRITICAL STREAM LENGTH,T64,11HMACH NUMBER,/T29,        000452
00364    83*          *19HREYNOLDS NUMBER,/)                                                000452
00365    84*          GO TO 150                                                             000452
00366    85*     127  WRITE(6,129)                                                         000454
00370    86*     150  WRITE(6,154) (REM(I),AM(I),I=1,NAM)                                  000461
00377    87*     154  FORMAT(T32,E10.6,T69,E10.6)                                         000476
00400    88*     145  CONTINUE                                                            000476
00401    89*          READ(5,5) (IMAT(I,1),I=1,NS)                                          000476
00407    90*      5   FORMAT(8I10)                                                        000512
00410    91*          READ(5,2) (ZSP(I),I=1,NS)                                             000512
00416    92*          READ(5,2) (RSP(I),I=1,NS)                                             000524
00424    93*          READ(5,2)(  PE(I),I=1,NS)                                             000536
00432    94*          READ(5,2) (HE(I),I=1,NS)                                              000550
00440    95*          READ(5,2)(UE(I) ,I=1,NS)                                              000562
00446    96*          READ(5,2) (TSP(I),I=1,NS)                                             000574
00454    97*          READ(5,2) (BPSP(I),I=1,NS)                                            000606
00462    98*          IF(IROUGH.EQ.1) READ(5,2) (RUF2(I),I=1,NS)                            000620
00471    99*          IF(IROUGH.EQ.0) GO TO 801                                             000635
00473   100*          DO 802 I=1,NS                                                         000642
00476   101*     802  RUF2(I)=RUF2(I)/12000.                                               000642
00500   102*     801  CONTINUE                                                            000646
00501   103*          IF(IPRNT.NE.9) GO TO 1101                                             000646
00503   104*          CALL LCOUNT(-8)                                                       000650
00504   105*          IF(IROUGH.EQ.1) WRITE(6,245)                                          000658
00507   106*          IF(IROUGH.EQ.0) WRITE(6,109)                                          000668
00512   107*     109  FORMAT(///T5,  8HMATERIAL,T20,5HAXIAL,T33,6HRADIAL,  T49,4HEDGE,    000673
00512   108*          *T69,4HEDGE,                                                          000673
00512   109*          *T79,  4HEDGE,T94,4HWALL,T109,10HNORMALIZED/T6  ,6HNUMBER,T19,        000673
00512   110*          *6HLENGTH,T33,6HLENGTH,T47,8HPRESSURE,T63,8HENTHALPY,T77,8HVELOCITY   000673
00512   111*          *,T92,11HTEMPERATURE,T108,13HABLATION RATE/T20,4HINCH,T34,4HINCH,     000673
00512   112*          *T49,3HATM,T63,7HBTU/LBM,T78,6HFT/SEC,T94,5HDEG R/T6,6H(IMAT),T20,    000673
00512   113*          *5H(ZSP),T34,5H(RSP),  T49,4H(PE),T64,4H(HE),T79,4H(UE),T94,          000673
00512   114*          *5H(TSP),T111,6H(BPSP)//)                                             000673
```

```
00513   115e
00513   116e
00513   117e
00513   118e
00513   119e
00513   120e
00513   121e
00513   122e
00513   123e
00513   124e
00513   125e
00514   126e
00514   127e
00515   128e
00516   129e
00521   130e
00523   131e
00525   132e
00525   133e
00541   134e
00541   135e
00584   136e
00550   137e
00555   138e
00556   139e
00557   140e
00560   141e
00561   142e
00563   143e
00570   144e
00571   145e
00572   146e
00575   147e
00578   148e
00576   149e
00601   150e
00605   151e
00604   152e
00607   153e
00612   154e
00612   155e
00612   156e
00612   157e
00613   158e
00615   159e
00616   160e
00620   161e
00622   162e
00623   163e
00624   164e
00625   165e
00626   166e
00631   167e
00633   168e
00642   169e
00645   170e
00652   171e

 248   FORMAT(///T5,  8HMATERIAL,T18,5HAXIAL,T29,6HRADIAL,  T42,4HEDGE,
     *T55,4HEDGE,
     *T68,  4HEDGE,T84,4HWALL,T99,  8HMATERIAL,T113,10HNORMALIZED/T6,
     *6HNUMBER,T18,
     *6HLENGTH,T29,6HLENGTH,T40,8HPRESSURE,T53,8HENTHALPY,    T66,8HVELOSITY
     *,T81,11HTEMPERATURE,T98,  9HROUGHNESS,T112,13HABLATION RATE/T19,
     *4HINCH,T30,4HINCH,
     *T42,5HATM,T53,7HBTU/LBM,T68,6HFT/SEC,T84,8HDEG R,T100,5HMIL/
     *T6,6H(IMAT),T19,
     *5H(ZSP),T30,5H(RSP),  T42,4H(PE),T55,4H(HE),T68,4H(UE),T84,
     *5H(TSP),T99,6H(RUFL),T115,6H(BPSP)//)
 119   FORMAT(T6,I5,T15,F10.5,T30,F10.5,T45,F10.4,T60,F10.3,T75,F10.5,
     *T90,F10.5,T106,F10.5)
1101   CONTINUE
       DO 6 I=1,NS
 111   IF(IABS(IMAT(I,1)).EQ.6) IMAT(I,1)=1
       IF(IPRNT.NE.9) GO TO 1111
       IF(IROUGH.EQ.1) WRITE(6,100)  IMAT(I,1),ZSP(I),RSP(I),PE(I),HE(I),
     *UE(I),TSP(I),RUF2(I),BPSP(I)
       IF(IROUGH.EQ.0) WRITE(6,110)  IMAT(I,1),ZSP(I),RSP(I),PE(I),HE(I),
     *UE(I),TSP(I),BPSP(I)
 100   FORMAT(T9,I1,T17,F8.4,T26,F8.4,T40,F8.4,T52,F9.5,T65,F9.5,T82,
     *F9.5,T98,F9.4,T114,F9.4)
       CALL LCOUNT(1)
1111   CONTINUE
       ZSP(I)=ZSP(I)/12.
       RSP(I)=RSP(I)/12.
    6  CONTINUE
       READ(5,4) IPMAX,INMAX,LTB
    4  FORMAT(3I3)
       IMM=INMAX+6
       CALL LCOUNT(-8)
       WRITE(6,200)
 200   FORMAT(/T49,19HTHERMODYNAMIC TABLE/T49,19(1H=)/)
       DO 9 I=1,IPMAX
       IF(LCT.GT.IMM) GO TO 112
       CALL LCOUNT(-1)
 112   READ(5,2) PT(I)
       WRITE(6,11)PT(I)
  11   FORMAT(//T48,11HPRESSURE = ,F7.3,5HATM//T22,8HENTHALPY,T40,
     *11HTEMPERATURE,T60,9HMOLECULAR,T80,9HVISCOSITY,T100,7HPRANDTL/
     *T22,9H(BTU/LBM),T42,7H(DEG R),T61,6HWEIGHT,T79,11H(LB/SEC-FT),
     *T100,6HNUMBER)
       IF(I.GT.1)  GO TO 201
       GO TO 203
 201   IF(PT(I).GT.PT(I-1))GO TO 203
       WRITE(6,204)
 204   FORMAT(///1X,39H********** WRONG PRESSURE INPUT ORDERING)
       STOP
 203   CONTINUE
       PLPT(I)=ALOG(PT(I))
       DO 6 J=1,INMAX
       IF(LTB.EQ.1) GO TO 701
       READ(5,7)  HT(J),TEMT(J,I),ENT(J,I),ET(J,I),GT(J,I)
  7    FORMAT(T21,F10.4,T40,F10.4,T58,F10.4,T78,F10.4,T99, F7.4 )
       WRITE(6,70) HT(J),TEMT(J,I),ENT(J,I),ET(J,I),GT(J,I)
       GO TO 702
```

```
00683   172e      701  READ(5,7) TEMT(J,I),HT(J),ENT(J,I),ET(J,I),GT(J,I)                    001137
00668   173e           WRITE(6,78) TEMT(J,I),HT(J),ENT(J,I),ET(J,I),GT(J,I)               001150
00671   174e      702  IF(J.GT.1) GO TO 205                                               001163
00673   175e           GO TO 16                                                           001166
00674   176e      205  IF(HT(J).GT.HT(J-1)) GO TO 16                                      001170
00676   177e           WRITE(6,208)                                                       001173
00700   178e      208  FORMAT(///1X,49H********** WRONG TEMPERATURE/ENTHALPY INPUT ORDERI,001200
00700   179e          *2HNG)                                                             001200
00701   180e           STOP                                                              001200
00702   181e      16   STOR(J,I)=HT(J)                                                    001203
00703   182e           IF(I.EQ.1)  GO TO 6                                               001204
00705   183e           IF(STOR(J,I).NE.STOR(J,I-1))  GO TO 17                            001206
00707   184e           GO TO 6                                                           001210
00710   185e      17   WRITE(6,18)                                                       001212
00712   186e      18   FORMAT(///1X,42H********** INPUT TEMPERATURE/ENTHALPY ERROR)     001216
00713   187e           STOP                                                              001216
00714   188e       6   CONTINUE                                                          001223
00716   189e           CALL LCOUNT(IHM)                                                  001223
00717   190e       9   CONTINUE                                                          001230
00721   191e       7   FORMAT(8E12.4,24X,E12.4,F8.4)                                     001230
00722   192e          12 FORMAT(9X,8E10.5)                                               001230
00723   193e           1 FORMAT(I3)                                                      001238
00724   194e           2 FORMAT(8F10.3)                                                  001238
00725   195e           MT2=ME(1)                                                         001238
00726   196e           THETSP(1)=ATAN((RSP(2)-RSP(1))/(ZSP(2)-ZSP(1)))                   001252
00727   197e           THETSP(NS)=ATAN((RSP(NS)-RSP(NS-1))/(ZSP(NS)-ZSP(NS-1)))          001244
00730   198e           NSM1=NS-1                                                         001257
00731   199e           DO 8 I=2,NSM1                                                     001262
00734   200e         8 THETSP(I)=ATAN((RSP(I+1)-RSP(I-1))/(ZSP(I+1)-ZSP(I-1)))          001266
00736   201e           STRAN=(ZSP(2)-ZSP(1))*0.01                                        001300
00737   202e           CALL VORTI                                                        001304
00740   203e           CALL REIT                                                         001306
00741   204e           CALL OUTPTI                                                       001310
00742   205e           CALL OUTPTV                                                       001312
00743   206e           END                                                               001316
```

```
00101     1*          SUBROUTINE ESTATE(IND,P,H,E,TEMP,EM,S,RO,A)
00103     2*
00103     3*    C
00103     4*    C-----------------------------------------------------------------------
00103     5*    C
00103     6*    C     THIS ROUTINE LOOKS UP THE PROPERTIES OF THE GAS USING THE TABLES
00103     7*    C
00103     8*    C-----------------------------------------------------------------------
00103     9*    C
00103    10*    C
00103    11*    C     *** INPUT ***
00103    12*    C     INDU = FLAG FOR SECOND INDEPENDENT VARIABLE
00103    13*    C           1 FOR ENTHALPY INPUT
00103    14*    C           3 FOR TEMPERATURE INPUT
00103    15*    C     P =    PRESSURE, ATM
00103    16*    C
00103    17*    C     *** OUTPUT ***
00103    18*    C     H =    ENTHALPY, BTU/LBM
00103    19*    C     E =    VISCOSITY, LBM/FT-SEC
00103    20*    C     T =    TEMPERATURE, DEG R
00103    21*    C     EM =   MOLECULAR WT., LBM/MOLE
00103    22*    C     S = PRANDTL NUMBER
00103    23*    C     RO =   DENSITY, LBM/FT3
00103    24*    C     A =    SPEED OF SOUND, FT/SEC
00103    25*    C
00103    26*    C
00103    27*          INCLUDE COMON
00110    28*          INCLUDE COMUNT
00112    29*          COMMON/TABLE/LTB
00113    30*          FLINE(X,XL,XU,YL,YU) = (X-XL)/(XU-XL)*(YU-YL)+YL
00113    31*    C
00113    32*    C     FIND PRESSURE INDEX
00113    33*    C
00114    34*          PLP = ALOG(P)
00115    35*          ISTRT=2                                                    000005
00116    36*          DO 10 IP=ISTRT,IPMAX                                       000006
00121    37*          IF (PLPT(IP).GT.PLP) GO TO 20                              000011
00125    38*       10 CONTINUE                                                   000017
00125    39*          IP = IPMAX                                                 000017
00126    40*       20 IP1 = IP-1                                                 000022
00126    41*    C     DO PLIP                                                    000022
00127    42*          IF(LTB.NE.1) GO TO 98                                      000024
00131    43*          IF(IND.EQ.1) INDU=3                                        000027
00135    44*          IF(IND.EQ.3) INDU=1                                        000034
00135    45*          IF(IND.EQ.1) TEMP=H                                        000041
00137    46*          IF(IND.EQ.3) H=TEMP                                        000046
00141    47*          GO TO 99                                                   000053
00142    48*       98 INDU=IND                                                   000055
00143    49*          GO TO (100,200,300), INDU                                  000057
00144    50*       200 CONTINUE                                                  000062
00145    51*          WRITE(5,1971)                                              000067
00147    52*       1971 FORMAT(' STOPPED IN ESTATE'/' IND CANNOT EQUAL 2')       000073
00150    53*          STOP                                                       000073
00150    54*    C                                                                000073
00150    55*    C     FIND INITIAL GUESS FOR ENTHALPY CORRESPONDING TO INPUT TEMPER.TURE  000073
00150    56*    C                                                                000073
00150    57*       300 CONTINUE                                                  000076
00152    58*          YGIVN = TEMP                                               000076
00155    59*          NCOUNT = 1                                                 000077
00156    60*          DO 310 IT=ISTRT,ITMAX                                      000112
00157    61*          IF (TEMT(IT,IP1).GT.TEMP) GO TO 320                        000112
00161    62*       315 CONTINUE                                                  000121
```

```
00163     63*          IT = IHMAX                                                    000121
00164     64*        320 IT1 = IT-1                                                  000124
00165     65*          HL = FLINE(TEMP,TEMT(IT1,IP1),TEMT(IT,IP1),HT(IT1),HT(IT))   000126
00166     66*          DO 330 IT=ISTRT,IHMAX                                         000161
00171     67*          IF (TEMT(IT,IP).GT.TEMP) GO TO 340                            000161
00173     68*        330 CONTINUE                                                    000170
00175     69*          IT = IHMAX                                                    000170
00176     70*        340 IT1 = IT-1                                                  000173
00177     71*          HU = FLINE(TEMP,TEMT(IT1,IP),TEMT(IT,IP),HT(IT1),HT(IT))      000175
00200     72*          H = FLINE(FLP,FLPT(IP1),FLPT(IP),HL,HU)                       000217
00200     73*      C                                                                 000217
00200     74*      C  *** START OF ITERATION LOOP ON ENTHALPY                        000217
00200     75*      C                                                                 000217
00201     76*        100 CONTINUE                                                    000233
00202     77*        120 DO 130 IH=ISTRT,IHMAX                                       000233
00205     78*          IF (HT(IH).GT.H) GO TO 140                                    000237
00207     79*        130 CONTINUE                                                    000245
00211     80*          IH = IHMAX                                                    000245
00212     81*        140 IH1 = IH-1                                                  000250
00213     82*          GO TO (150,150,180), INDU                                     000252
00213     83*      C                                                                 000252
00213     84*      C     LOOK UP VISCOSITY FROM ENTHALPY AND PRESSURE                000252
00213     85*      C                                                                 000252
00214     86*        150 CONTINUE                                                    000263
00215     87*        160 EL = FLINE(H,HT(IH1),HT(IH),ET(IH1,IP1),ET(IH,IP1))       000263
00216     88*          EU = FLINE(H,HT(IH1),HT(IH),ET(IH1,IP),ET(IH,IP))           000305
00217     89*        170 E = FLINE(FLP,FLPT(IP1),FLPT(IP),EL,EU)                   000320
00217     90*      C                                                                 000320
00217     91*      C     LOOK UP TEMPERATURE FROM ENTHALPY AND PRESSURE              000320
00217     92*      C                                                                 000320
00220     93*        180 TL = FLINE(H,HT(IH1),HT(IH),TEMT(IH1,IP1),TEMT(IH,IP1))   000334
00221     94*          TU = FLINE(H,HT(IH1),HT(IH),TEMT(IH1,IP),TEMT(IH,IP))       000355
00222     95*          TEMP = FLINE(FLP,FLPT(IP1),FLPT(IP),TL,TU)                  000370
00223     96*          GO TO (550,550,420), INDU                                   000403
00224     97*        420 YIND = TEMP                                               000414
00225     98*        430   IF(YGIVN.EQ.0.) GO TO 440                              000415
00227     99*          IF(ABS(YIND-YGIVN)/YGIVN.LT..00010) GO TO 500               000417
00231    100*          GO TO 450                                                   000425
00232    101*        440   IF(ABS(YIND-YGIVN).LT..00100) GO TO 500                000427
00234    102*        450   CALL XSOLVE(H,YIND,YGIVN,NCOUNT,XLO,YLO,XHI,YHI)       000435
00253    103*          GO TO 100                                                   000446
00253    104*      C                                                               000446
00253    105*      C  *** END OF ITERATION LOOP ON ENTHALPY                        000446
00253    106*      C                                                               000446
00256    107*        500 CONTINUE                                                  000450
00257    108*          GO TO (550,200,520), INDU                                   000450
00260    109*        520 EL = FLINE(H,HT(IH1),HT(IH),ET(IH1,IP1),ET(IH,IP1))       000460
00261    110*          EU = FLINE(H,HT(IH1),HT(IH),ET(IH1,IP),ET(IH,IP))           000501
00262    111*        530 E = FLINE(FLP,FLPT(IP1),FLPT(IP),EL,EU)                   000514
00265    112*          TEMP = YGIVN                                                000527
00266    113*        550 CONTINUE                                                  000532
00266    114*      C                                                               000532
00266    115*      C     LOOK UP MOLECULAR WT. AND GAMMA FROM ENTHALPY AND PRESSURE  000532
00266    116*      C     AND CALCULATE DENSITY AND SPEED OF SOUND                    000532
00266    117*      C                                                               000532
00267    118*          EML = FLINE(H,HT(IH1),HT(IH),EMT(IH1,IP1),EMT(IH,IP1))      000532
00270    119*          EMU = FLINE(H,HT(IH1),HT(IH),EMT(IH1,IP),EMT(IH,IP))        000554
```

```
00247    120*          ER = FLINE(FLP,FLPT(IP1),FLPT(IP),ERL,ERU)                    000567
00250    121*          GL = FLINE(H,MT(IM1),MT(IM),GT(IM1,IP1),GT(IM,IP1))           000602
00251    122*          GU = FLINE(H,MT(IM1),MT(IM),GT(IM1,IP),GT(IM,IP))             000607
00252    123*          G = FLINE(FLP,FLPT(IP1),FLPT(IP),GL,GU)                       000614
00253    124*          IF(LTB.NE.1) GO TO 510                                        000625
00255    125*          TSTORE=TEMP                                                   000630
00256    126*          TEMP=H                                                        000632
00257    127*          H=TSTORE                                                      000634
00260    128*    510   CONTINUE                                                     000636
00261    129*          RO = P/(TEMP*RU/ER)                                           000636
00262    130*          A=SQRT(GAM2*P/RO*GC*ATM*FT2)                                  000643
00263    131*          RETURN                                                        000656
00264    132*          END                                                           000770
```

```
00101     1*          SUBROUTINE HSHAPE(I,ILT,SHPFAC)
00101     2*    C
00101     3*    C-----------------------------------------------------------------------
00101     4*    C
00101     5*    C     THIS ROUTINE COMPUTES THE LAMINAR AND TURBULENT SHAPE FACTORS
00101     6*    C
00101     7*    C-----------------------------------------------------------------------
00101     8*    C
00103     9*          INCLUDE COMON
00110    10*          GO TO (10,20), ILT
00111    11*       10 CONTINUE
00112    12*          SHPFAC=3.029*TW(I)/TE(I)-0.614                                  000010
00113    13*          GO TO 30                                                        000018
00114    14*       20 CONTINUE                                                        000019
00115    15*          ALRETH=ALOG(RETH(I))                                            000016
00116    16*          EN=(0.37*ALRETH)/(2.79-0.14*ALRETH)                             000016
00117    17*          SHPFAC=2.285*(1.+3.2*EXP(-EN))*TW(I)/TE(I)-0.96                 000025
00120    18*       30 CONTINUE                                                        000031
00121    19*          RETURN                                                          000045
00122    20*          END                                                             000045
                                                                                     000062
```

```
00101    1*          SUBROUTINE LARAU6(I,RSRL)
00103    2*          INCLUDE COMON
00110    3*          INCLUDE COMUNT
00112    4*          NCOUNT=1
00113    5*          IDEBU6=0                                                    000002
00114    6*          RSRLO=0.                                                    000003
00114    7*    C                                                                 000003
00115    8*       10 SOTKL=STRAN/THE(I)/RSRL**1.3                              000005
00116    9*          IF(NREYCR.EQ.4)  SOTKL=STRAN/THE(I)/RSRL                    000016
00120   10*          IF(SOTKL.GT.1000.)  GO TO 20                                000024
00122   11*          DUMMY=RSRL-7.6/SOTKL**0.366*EXP(5.E-04*SOTKL)               000030
00123   12*          IF(ABS(RSRL-RSRLO)/RSRL.LT..01)  GO TO 20                   000050
00125   13*          RSRLO=RSRL                                                  000057
00125   14*    C                                                                 000057
00126   15*          CALL XSOLVE(RSRL,DUMMY,0.,NCOUNT,XLO,YLO,XHI,YHI)           000061
00126   16*    C                                                                 000061
00127   17*          IF(IDEBUG.EQ.1)                                             000073
00127   18*         $WRITE(6,100) NCOUNT,RSRLO,RSRL,SOTKL,DUMMY,STRAN,THE(I)     000078
00141   19*      100 FORMAT(1H0,62HNCOUNT,RSRLO,RSRL,SOTKL,DUMMY,STRAN,THE(I)/1X,I3,1X,  000112
00141   20*         $1P6E12.5)                                                   000112
00142   21*          GO TO 10                                                    000112
00143   22*       20 CONTINUE                                                    000114
00144   23*          IF(RSRL.LT.1.)  RSRL=1.                                     000114
00146   24*          IF(RSRL.GT.5.) RSRL=5.                                      000121
00150   25*          RETURN                                                      000127
00151   26*          END                                                         000157
```

```
00101      1*          SUBROUTINE LCOUNT(I)
00101      2*    C
00101      3*    C-----------------------------------------------------------------------
00101      4*    C
00101      5*    C     THIS ROUTINES COUNTS, TITLES AND NUMBERS EACH PAGE
00101      6*    C
00101      7*    C-----------------------------------------------------------------------
00101      8*    C
00101      9*    C     *** INPUT ***
00101     10*    C     I = NUMBER OF LINES TO BE WRITTEN IN SUCCEEDING WRITE STATEMENTS
00101     11*    C     IN THE CALLING ROUTINE
00101     12*    C     NOTE*  TO START A NEW PAGE USE NEGATIVE I
00101     13*    C
00103     14*          INCLUDE COMON
00110     15*          DATA LCTMAX/ 54 /
00110     16*    C
00110     17*    C     LCTMAX IS THE MAXIMUM NUMBER OF LINES ON A PAGE
00110     18*    C
00112     19*          J = I
00113     20*          IF (J.LT.0) GO TO 10                                          000081
00113     21*    C                                                                   000081
00113     22*    C     SUBTRACT J FROM THE LINE COUNT AND CHECK IF NEW PAGE IS REQUIRED 000081
00113     23*    C                                                                   000081
00115     24*          LCT = LCT-J                                                   000001
00116     25*          IF (LCT.GE.0) RETURN                                          000003
                                                                                    000086
00120     26*          J = -J                                                        000014
00120     27*    C                                                                   000014
00120     28*    C     INCREMENT PAGE COUNT AND START NEW PAGE                       000014
00120     29*    C                                                                   000014
00121     30*       10 NPG = NPG+1                                                   000017
00122     31*          LCT = LCTMAX+J                                                000021
00123     32*          WRITE(6,20)                                                   000024
00125     33*       20 FORMAT(1H1,40X,44HMOMENTUM ENERGY INTEGRATION TECHNIQUE (MEIT)) 000031
00124     34*          RETURN                                                        000031
00127     35*          END                                                           000042
```

```
00101      1*          SUBROUTINE MEIT
00103      2*          INCLUDE COMON
00110      3*          INCLUDE COMUNT
00112      4*          COMMON/RUFF/IROUGH,RUF2(150)
00113      5*          COMMON/PRCAL/PRL,PRT
00114      6*          DIMENSION OPF(150),OTF(150),EMW(150),ZETA(150),CI(150),DPDS(150),
00114      7*         *STORE(25),UEIP(150)
00114      8*     C-----
00115      9*          IDEBUG=0
00115     10*     C *** ASSIGN INITIAL OR KNOWN VALUES
00116     11*          CALL ESTATE(1,PE(1),HE(1),VISE(1),TE(1),EMW(1),PRE,ROE(1),AE)
00117     12*          CALL ESTATE(3,PE(1),HW(1),VISW(1),TSP(1),EMWW,PRW,ROW(1),AW)                    000018
00120     13*          HPR=.42*HE(1)+.58*HW(1)+.19*(PRW**.5)*UE(1)**2./6C/BTU/2.                       000026
00121     14*          CALL ESTATE(1,PE(1),HPR,VISPR,TR,EMPR,PR,ROPR,APR)                              000051
00122     15*          RECOV=SQRT(PR)                                                                  000064
00123     16*          DO 3 I=1,NTT                                                                    000075
00126     17*          SOR(I)=S(I)/RN                                                                  000075
00127     18*          ZETA(I)=0.25*(SOR(I)**2)-0.25*SOR(I)*SIN(2.0*SOR(I))-                           000077
00127     19*         *          0.125*COS(2.0*SOR(I))                                                000077
00130     20*          RUCH(I)=0.0                                                                     000122
00131     21*          TUE(I)=0.0                                                                      000123
00132     22*          AOML(I)=0.0                                                                     000124
00133     23*        3 CONTINUE                                                                        000126
00135     24*          RAF(1) = RECOV                                                                  000126
00136     25*          HR(1)=HT2                                                                       000130
00137     26*          HCAM(1)=0.0                                                                     000132
00140     27*          URE(1)=0.0                                                                      000133
00141     28*          YBAR(1)=0.0                                                                     000134
00142     29*          RETH(1)=0.0                                                                     000135
00143     30*          REPH(1)=0.0                                                                     000136
00144     31*          CSEE(1)=0.0                                                                     000137
00145     32*          BETP(1)=0.5                                                                     000140
00146     33*          BETP(2)=0.5                                                                     000142
00147     34*          CI(1)=0.0                                                                       000143
00150     35*          STIRA6=1.                                                                       000144
00151     36*          UE(1) = 0.0                                                                     000146
00152     37*          TUT = 0.0                                                                       000147
00153     38*          HSFT = 0.0                                                                      000150
00154     39*          RCT = 0.0                                                                       000151
00155     40*          RSRL=1.                                                                         000152
00156     41*          RSRT=1.                                                                         000153
00157     42*          RATIO=0.                                                                        000154
00160     43*          NOSTRN=0                                                                        000155
00161     44*          STRAN = 1.E10                                                                   000156
00161     45*     C    ***********                                                                     000156
00162     46*          IF(IROUGH.EQ.1)  RUF(1)=RUF2(1)                                                 000160
00164     47*          IF(IROUGH.EQ.0) CALL RUFNES(1,RUF(1))                                           000165
00164     48*     C    ***********
```

```
00164    49*     C *** FILL IN INTEGRATION POINT VARIABLES DEFINED AT BODY POINTS                    000165
00166    50*           IF(UE(1).LT..00000001) UE(1)=1.0                                             000165
00170    51*           DO 9999 IX=1,NS                                                              000173
00173    52*     9999  PE(IX)=ALOG(PE(IX))                                                          000212
00175    53*           DO 7 I=1,NTT                                                                 000212
00200    54*           CALL TBLP(S(I),SP,TW(I),TSP,NS)                                              000223
00201    55*           CALL TBLP(S(I),SP,BP(I),BPSP,NS)                                             000223
00202    56*           CALL TBLP(S(I),SP,HW(I),HE,NS)                                               000235
00203    57*           IF(IROUGH.EQ.1) CALL TBLP(S(I),SP, RUF(I),RUF2,NS)                           000250
00205    58*           CALL TBLP(S(I),SP,UEIP(I),UE,NS)                                             000263
00206    59*           CALL TBLP(S(I),SP,PEPI(I),PE,NS)                                             000301
00207    60*           IF(BP(I).LT..000001) BP(I)=.000001                                           000314
00211    61*         7 CONTINUE                                                                     000327
00213    62*           NSM1=NS-1                                                                    000337
00214    63*           I=0                                                                          000337
00215    64*           DO 995 IXX=1,NTT                                                             000342
00220    65*           HE(IXX)=HW(IXX)                                                              000350
00221    66*           PEPI(IXX)=EXP(PEPI(IXX))                                                     000350
00222    67*           UE(IXX)=UEIP(IXX)                                                            000351
00223    68*           PE(IXX)=PEPI(IXX)                                                            000357
00224    69*       995 PEPI(IXX)=PEPI(IXX)/PE(1)                                                    000361
00226    70*           IF(UE(1).LE.1.0)  UE(1)=0.                                                   000362
00230    71*           NTTM1=NTT-1                                                                  000365
00231    72*           DO 27 I=2,NTTM1                                                              000372
00234    73*        27 CALL GADRTC(2,S(I-1),S(I),S(I+1),S(I),PE(I-1),PE(I),PE(I+1),DPDS(I        000375
00234    74*          *))                                                                           000401
00236    75*           DPDS(1)=0.0                                                                  000401
00237    76*           DPDS(NTT)=DPDS(NTT-1)                                                        000434
00240    77*           I1=2                                                                         000435
00241    78*           IF (IDEBUG.EQ.1)                                                             000440
00241    79*          *WRITE(6,1001) I1,PEPI(I1),UE(I1)                                             000442
00247    80*       1001 FORMAT(15X,18HI1,PEPI(I1),UE(I1)/10X,I5,2E15.6)                             000442
00250    81*           ALFA=(1.0-PEPI(I1))/(SOR(I1)**2)                                             000461
00251    82*           OUDZ=(UE(2)-UE(1))/(S(2)-S(1))                                               000461
00251    83*     C *** COMPUTE WALL PROPERTIES                                                      000470
00252    84*           DO 45 I=1,NTT                                                                000470
00255    85*           CALL ESTATE(3,PE(I),HW(I),VISW(I),TW(I),EMWW,PRW,ROW(I),AW)                  000503
00256    86*        45 CONTINUE                                                                     000503
00256    87*     C ***              BEGINNING OF LOOP TO CALCULATE                                  000530
00256    88*     C ***        LAMINAR AUG. DUE TO TRANSITION PROXIMITY, RSRL                        000530
00260    89*           KLIT=0                                                                       000530
00260    90*     C     ************************************************************************** 000530
```

```
00261     91*        54 CONTINUE                                                                  000532
00262     92*           KLIT=KLIT+1                                                               000532
00262     93*     C     ***************************************************************           000532
00263     94*           MAT = MATL(1)                                                             000532
00264     95*           IF(IDEBUG.EQ.1)                                                           000534
00264     96*          *WRITE(6,1006) KLIT,STRAN,THE(1),RSRL                                      000536
00273     97*      1006 FORMAT(1HD,22HKLIT,STRAN,THE(1),RSRL  /1X,I3,3X,1P3E15.6)                 000536
00273     98*     C                                                                             000563
00274     99*           IF(NOSTRN.EQ.1.AND.JROUGH(1).GT.0.AND.KLIT.GT.1)                          000563
00274    100*          $ CALL LAMAUG(1,RSRL)                                                      000563
00274    101*     C                                                                             000563
00276    102*           RSRLA=RSRL**2                                                             000563
00277    103*           DUDS=DUDZ                                                                 000612
00300    104*           LTT=1                                                                     000615
00300    105*     C *** ITERATE S.P. SOLUTIONS                                                    000617
00301    106*           DO 60 ITER=1,3                                                            000617
00304    107*           CALL SR1(1,C1,C2)                                                         000628
00304    108*     C     ************                                                              000628
00305    109*           CALL MSHAPE(1,1,MSF(1))                                                   000628
00305    110*     C     ************                                                              000627
00306    111*           THE(1)=SQRT(C1*(1.0+RAF(1)*BP(1)*CMH(1))*VISE(1)/                         000627
00306    112*          *       (ROE(1)*(3.0+MSF(1))*DUDS))                                        000634
00307    113*           PHI(1)=SQRT(C2*(1.0+BP(1)*CMH(1))*VISE(1)/(2.0*ROE(1)*DUDS))              000634
00310    114*           RAF(1)=C2*THE(1)/(C1*PHI(1.)                                              000654
00311    115*        60 CONTINUE                                                                  000672
00313    116*           THE(1)=THE(1)*RSRL                                                        000708
00314    117*           PHI(1)=PHI(1)*RSRL                                                        000708
00315    118*           C1=C1*RSRLA                                                               000708
00316    119*           C2=C2*RSRLA                                                               000706
00317    120*           RUCH(1)=C2*VISE(1)/PHI(1)                                                 000711
00320    121*           TUE(1)=0.0                                                                000714
00321    122*           RUFSMT(1)=RSRL                                                            000717
00322    123*           IF(KLIT.EQ.1) RUCHN=RUCH(1)                                               000720
00324    124*           METAUS=RUCH(1)/RUCHN                                                      000722
00325    125*           DTF(1)=0.0                                                                000727
00326    126*           DPF(1)=0.0                                                                000732
00326    127*     C *** SERIES SOLUTION FOR I=2,3                                                 000733
00327    128*           GAMB = (GAM2-1.)/GAM2                                                     000733
00330    129*           A=(0.3333+(13.0*MSF(1))*ALFA/(4.0*GAM2)-                                  000734
00330    130*          $ (MSF(1)+0.614)*ALFA*GAMB-0.659*ALFA*GAMB*(3.0+MSF(1)))/                  000748
00330    131*          $ (8.0+2.0*MSF(1))                                                         000748
00331    132*           B=(0.3333+3.0*ALFA/GAM2-                                                  000748
00331    133*          $ 1.318*ALFA*GAMB-2.0*ALFA*GAMB*(1.0-RECOV)*(1.0+BP(1)*CMH(1))/           000770
00331    134*          $ (1.0-TW(1)/TE(1)))/6.                                                    000770
00331    135*     C                                                                             000770
00332    136*           DO 63 I=2,3                                                               000770
00332    137*     C     ************                                                              001025
00335    138*           IF(IROUGH.EQ.1) GO TO 2001                                                001025
00337    139*           CALL RUFNES(I,RUF(I))                                                     001029
00340    140*     2001  CONTINUE                                                                  001038
00340    141*     C     ************                                                              001037
00341    142*           THE(I)=THE(1)*(1.0+A*(SOR(I)**2))                                         001037
00342    143*           PHI(I)=PHI(1)*(1.0+B*(SOR(I)**2))                                         001037
00343    144*           UE(I)=DUDZ*S(I)*(1.0+ALFA*(SOR(I)**2)/(4.0*GAM2))                         001045
00344    145*           ROE(I)=ROE(1)*(1.0-ALFA*(SOR(I)**2)/GAM2)                                 001052
00345    146*           MAT1 = MAT                                                                001065
00346    147*           MAT = MATL(I)                                                             001072
                                                                                                 001079
```

```
00346   148*      C *** USE AE AND TE AT PREVIOUS STATION
00347   149*            MCAR(I)=UE(I)/AE                                                    001074
00350   150*            TE(I)=TE(I-1)                                                       001076
00350   151*      C     ***********                                                         001100
00351   152*            CALL HSHAPE(I,1,HSF(I))                                             001100
00351   153*      C     ***********                                                         001102
00352   154*            YBAR(I)=0.0                                                         001102
00353   155*            CALL ESTATE(1,PE(I),HE(I),VISE(I),TE(I),EMW(I),PRE,ROE(I),AE)       001111
00354   156*            HR(I)=HE(I)+RECOV*UE(I)**2/2./BTU/GC                                001112
00355   157*            RUCH(I)=C2*VISE(I)/PHI(I)                                           001141
00356   158*            TUE(I)=C1*VISE(I)/THE(I)                                            001151
00357   159*            RJFSMT(I) = RSRL                                                    001155
00360   160*            RAF(I)=C2*THE(I)/(C1*PHI(I))                                        001161
00361   161*            DUDS=DUDZ*(1.0+0.75*ALFA*(SOR(I)**2)/6AR2)                          001163
00362   162*            DTF(I)=R(I)*UE(I)*TUE(I)*(1.0+RAF(I)*BP(I)*CMH(1))                  001171
00363   163*            HT2=HE(I)+UE(I)**2/2./GC/BTU                                        001200
00364   164*            DPF(I)=R(I)*RUCH(I)*(HR(I)-HW(I)+(HT2-HW(I))*BP(I)*CMH(1))          001210
00365   165*            URE(I)=ROE(I)*UE(I)/VISE(I)                                         001217
00366   166*            RETH(I) = URE(I)*THE(I)                                             001227
00367   167*            REPH(I) = URE(I)*PHI(I)                                             001233
00370   168*            CI(I)=ROE(I)*VISE(I)*UE(I)*R(I)*R(I)                                001235
00371   169*            IF (I.EQ.3) GO TO 62                                                001240
00373   170*            CSEE(2)=RN*RN*CI(2)*(ZETA(2)+0.125)/(S'2)*((SIN(SOR(2)))**2))       001246
00374   171*            GO TO 63                                                            001251
00375   172*         62 CSEC(3)=CSEE(2)+                                                    001264
00375   173*           1        0.5*RN*RN*(CI(3)/(S(3)*((SIN(SOR(3)))**2))+                001266
00375   174*           2                  CI(2)/(S'2)*((SIN(SOR(2)))**2)))*               001266
00375   175*           3        (ZETA(3)-ZETA(2))                                          001266
00376   176*            BETP(3)=2.0*CSEE(3)*DUDS/(CI(3)*UE(3))                             001266
00376   177*      C                                                                        001315
00377   178*         63 CONTINUE                                                           001315
00377   179*      C                                                                        001326
00377   180*      C *** SOLUTIONS FOR I GREATER THAN 3                                     001326
00401   181*            IF (IDEBUG.NE.0)                                                   001326
00401   182*           *WRITE (6,1002)                                                     001326
00404   183*       1002 FORMAT (1H1)                                                      001326
00405   184*            I=4                                                               001335
00405   185*      C     ***************************************************************** 001335
00406   186*         65 CONTINUE                                                           001335
00406   187*      C     ***************************************************************** 001340
00407   188*            MAT1 = MAT                                                        001340
00410   189*            MAT = MATL(I)                                                     001340
00411   190*            RAF(I)=RAF(I-1)                                                   001341
00412   191*            HSF(I)=HSF(I-1)                                                   001344
00413   192*            THE(I)=THE(I-1)                                                   001346
00414   193*            PHI(I) = PHI(I-1)                                                 001350
00415   194*            RUF(I) = RUF(I-1)                                                 001352
00416   195*            RUCH(I)=RUCH(I-1)                                                 001354
00417   196*            TUE(I) = TUE(I-1)                                                 001356
00420   197*            DTF(I) = DTF(I-1)                                                 001360
00421   198*            DPF(I) = DPF(I-1)                                                 001362
00421   199*      C *** ITERATION ON SOLUTION OF MEIT EQNS                                001364
00422   200*            RESID=0.                                                          001364
00423   201*            THEN=THE(I)                                                       001366
00424   202*            RESIP = 0.                                                        001367
00425   203*            PHIN = PHI(I)                                                     001370
00426   204*            IF(I.EQ.NTT) GO TO 165                                            001371
                                                                                        001372
```

```
00430    205*          CALL GADRTC(2,S(I-1),S(I),S(I+1),S(I),UE(I-1),UE(I),UE(I+1),DUDS)                    001475
00431    206*      165 CONTINUE                                                                             001476
00432    207*          CALL ESTATE(1,PE(I),HE(I),VISE(I),TE(I),EMW(I),PRE,ROE(I),AE)                        001477
00433    208*          HCAM(I)=UE(I)/AE                                                                     001478
00433    209*      C                                                                                        001479
00434    210*          DO 160  ITER=1,30                                                                    001480
00434    211*      C                                                                                        001481
00437    212*          RESIDE=RESID                                                                         001482
00440    213*          THEO=THEN                                                                            001483
00441    214*          THEN=THE(I)                                                                          001484
00442    215*          RESIPE = RESIP                                                                       001502
00443    216*          PHIO = PHIN                                                                          001504
00444    217*          PHIN = PHI(I)                                                                        001506
00445    218*          TUEOLD=TUE(I)                                                                        001510
00446    219*          RUCHO=RUCH(I)                                                                        001512
03446    220*      C                   ***********                                                          001512
00447    221*          IF(ITER.GT.1.AND.IROUGH.EQ.1) GO TO 2002                                             001514
00451    222*          IF (ITER.GT.1) CALL RUFNES(I,RUF(I))                                                 001531
00453    223*      2002  CONTINUE                                                                           001547
00453    224*      C                   ***********                                                          001547
00454    225*          URE(I)=ROE(I)*UE(I)/VISE(I)                                                          001547
00454    226*      C *** COMPUTE LAMINAR PRESSURE GRADIENT PARAMETER                                        001547
00455    227*          CI(I)=ROE(I)*VISE(I)*UE(I)*R(I)*R(I)                                                 001553
00456    228*          IF (I.GT.I1) GO TO 85                                                                001561
00460    229*          CSEE(I)=CSEE(I-1)+                                                                   001565
00460    230*         1        0.5*RN*RN*(CI(I)/(S(I)*((SIN(SOR(I)))**2))+                                001565
00460    231*         2                 CI(I-1)/(S(I-1)*((SIN(SOR(I-1)))**2)))*                           001565
00460    232*         3        (ZETA(I)-ZETA(I-1))                                                        001565
00461    233*          GO TO 87                                                                             001624
00462    234*       85 CSEE(I)=CSEE(I-1)+0.5*(CI(I)+CI(I-1))*(S(I)-S(I-1))                                  001626
00463    235*       87 BETP(I)=2.0*CSEE(I)*DUDS/(CI(I)*UE(I))                                               001637
00463    236*      C *** COMPUTE MOMENTUM AND ENERGY THICKNESSES                                            001637
00464    237*          DELS=S(I)-S(I-1)                                                                     001646
00465    238*          TERM1=R(I-1 *ROE(I-1)*UE(I-1)                                                        001651
00466    239*          TERM2=R(I)*ROE(I)*UE(I)                                                              001655
00467    240*          TERM3=GC*ATM*FT2                                                                     001661
00470    241*          THE(I)=(TERM1*UE(I-1)*THE(I-1)/DELS+.5*(DTF(I)+DTF(I-1))+.5*R(I-1)                   001665
00470    242*         $       *HSF(I-1)*DPDS(I-1)*TERM3*THE(I-1))/(TERM2*UE(I)/DELS                         001665
00470    243*         $       -.5*R(I)*HSF(I)*DPDS(I)*TERM3)                                                001665
00471    244*          HT2=HE(I)+UE(I)**2/2./GC/BTU                                                         001715
00472    245*          PHI(I) = (TERM1*(HT2 - HW(I-1))*PHI(I-1) + .5*(DPF(I) + DPF(I-1))                    001724
00472    246*         1          *DELS)/TERM2/(HT2 - HW(I))                                                 001724
00473    247*          RESID=THEN-THE(I)                                                                    001741
00474    248*          RESIP = PHIN - PHI(I)                                                                001743
00475    249*          IF(IDEBUG.NE.0)                                                                      001746
00475    250*         $WRITE(6,1008) RESIDE,RESID,THE(I),THEN,THEO,DTF(I),DTF(I-1),RAF(I)                   001746
00475    251*         * ,HSF(I),S(I),RESIPE,RESIP,PHI(I),PHIN,PHIO                                          001746
00475    252*         $                ,DPF(I),DPF(I-1),DPDS(I)                                             001746
00522    253*       1008 FORMAT(1H0,12(7HRESIDE,RESID,THE(I),THEN,THEO,DTF(I),DTF(I-1),RAF(I                 002001
00522    254*         *),HSF(I),S(I),RESIPE,RESIP,PHI(I),PHIN,PHIO ,DPF(I),DPF(I-                         002001
00522    255*         $1),DPDS(I)/1X,(1P10E11.4))                                                          002001
00523    256*          IF (ITER.LE.2) GO TO 89                                                              002001
00525    257*          IF (ABS(RESID-RESIDE).LT.1.E-10) GO TO 89                                            002001
00527    258*          THE(I) = THEN-(THEN-THEO)*RESID/(RESID-RESIDE)                                       002005
00530    259*          RAT = THE(I)/THEN                                                                    002013
00531    260*          IF (RAT.GT.2.,OR.RAT.LT..5) THE(I) = THEN-RES.0                                      002024
00533    261*       89 CONTINUE                                                                             002026
                                                                                                           002051
```

```
00534   262*          IF (THE(I).LE.0.) THE(I) = THEN                                          002052
00536   263*          IF (ITER.LE.2) GO TO 88                                                  002060
00540   264*          IF (ABS(RESIP-RESIPE).LT.1.E-10) GO TO 88                                002064
00542   265*          PHI(I) = PHIN - (PHIN - PHIO)*RESIP/(RESIP - RESIPE)                     002072
00543   266*          RAT = PHI(I)/PHIN                                                        002103
00544   267*          IF (RAT .GT. 2 .OR. RAT .LT. .5) PHI(I) = PHIN - RESIP                   002105
00546   268*       88 CONTINUE                                                                 002130
00547   269*          IF (PHI(I).LE.0.) PHI(I) = PHIN                                          002131
00551   270*          RETH(I) = URE(I)*THE(I)                                                  002131
00551   271*          REPH(I) = URE(I)*PHI(I)                                                  002137
00552   272*    C *** COMPUTE LAMINAR INPUTS TO MEIT                                           002143
00553   273*          IF(IDEBUG.NE.0)                                                          002143
00553   274*         *WRITE(6,999) I,ITER,LTT,DUDS,DUDZ,UE(I),CI(I),CSEE(I),BETP(I),          002146
00553   275*         *HE(I),PE(I),THE(I),PHI(I)                                               002146
00573   276*        999 FORMAT(1H0,62HFROM MEIT  I,ITER,LTT,DUDS,DUDZ,UE,CI,CSEE,BETP,HE,     002146
00573   277*         $PE,THE,PHI /1X,3I5,/1X,8(E15.6))                                        002174
00574   278*          IF(LTT.EQ.3)  GO TO 100                                                  002174
00574   279*    C     ********                                                                 002174
00576   280*          CALL SR1(I,C1,C2)                                                        002174
00576   281*    C     ********                                                                 002177
00577   282*          TUL=C1*VISE(I)/THE(I)                                                    002177
00600   283*          RCL=C2*VISE(I)/PHI(I)                                                    002205
00601   284*          IF (S(I).GE.STRAN) GO TO 90                                              002211
00603   285*          TUL=TUL*RSRLA                                                            002215
00604   286*          RCL=RCL*RSRLA                                                            002221
00605   287*       90 CONTINUE                                                                 002223
00606   288*          IF (IDEBUG.NE.0)                                                         002226
00606   289*         *WRITE(6,998) I,LTT,TUL,C1,C2,BETP(I),BP(I)                               002227
00620   290*        998 FORMAT(15X,2HI,LTT,TUL,C1,C2,BETP(I),BP(I)/10X,2I3,1P5E15.6)           002227
00620   291*    C     ***********                                                              002247
00621   292*          CALL HSHAPE(I,1,HSFL)                                                    002247
00621   293*    C     ***********                                                              002247
00622   294*          IF (LTT.EQ.1) GO TO 120                                                  002247
00622   295*    C *** COMPUTE TURBULENT INPUTS TO MEIT                                         002254
00622   296*    C     ********                                                                 002254
00624   297*        100 CALL SR2 (I, CFO2, CH, RSRTM, RSRTH)                                   002254
00624   298*    C     ********                                                                 002260
00625   299*          TUTS=ROE(I)*UE(I)*CFO2                                                   002260
00626   300*          TUT = RSRTM*TUTS                                                         002267
00627   301*          IF (LTT.LT.3.AND.TUT.LT.TUL) TUT=TUL                                     002273
00627   302*    C                                                                              002276
00631   303*          RCTS=ROE(I)*UE(I)*CH                                                     002276
00632   304*          RCT = RSRTH*RCTS                                                         002316
00633   305*          IF (LTT.LT.3.AND.RCT.LT.RCL)  RCT=RCL                                    002323
00635   306*          RSRT=RCT/RCTS                                                            002325
00635   307*    C     ***********                                                              002345
00636   308*          CALL HSHAPE(I,2,HSFT)                                                    002345
00636   309*    C     ***********                                                              002350
00637   310*          IF (LTT.EQ.3) ADML(I)=1.0                                                002350
00641   311*          IF (LTT.EQ.2) GO TO 118                                                  002357
00643   312*          GO TO 120                                                                002365
00643   313*    C *** COMPUTE INTERMITTENCY,PERSCH                                             002370
00644   314*        118 TUE(I)=TUT-ROE(I)*UE(I)*THNP/RETH(I)**PERSH                            002370
00645   315*          IF(IDEBUG.NE.0)                                                          002372
00645   316*         *WRITE(6,1005) TUE(I),TUL,TUT,TUTS,RSRTM,RCL,RCT,RCTS,RSRTH,CFO2,CH       002411
00663   317*       1005 FORMAT(1H0,49HTUE,TUL,TUT,TUTS,RSRTM,RCL,RCT,RCTS:RSRTH,CFO2,CH       002411
00663   318*         * (/8E15.6))                                                             002435
                                                                                             002435
```

```
00664   319*          IF(ABS(TUT-TUL).LT.1.E-7)  GO TO 119                                  002435
00666   320*          ADML(I)=(TUE(I)-TUL)/(TUT-TUL)                                        002443
00667   321*          IF(ADML(I).LT.0.)  ADML(I)=1.                                         002452
00671   322*          IF (ADML(I).GT.0.999) LTT=3                                           002460
00673   323*          GO TO 120                                                             002467
00674   324*      119 LTT=0                                                                 002471
00675   325*          ADML(I)=0.                                                            002472
00676   326*          INXT = I                                                              002473
00676   327*      C *** COMPUTE TRANSITIONAL MIX                                            002473
00677   328*      120 CONTINUE                                                              002476
00700   329*          PR=PRL+ADML(I)*(PRT-PRL)                                              002502
00701   330*          RECOV=SQRT(PRL)+ADML(I)*(PRT**0.3333-SQRT(PRL))                       002507
00702   331*          TUE(I)=TUL+ADML(I)*(TUT-TUL)                                          002520
00703   332*          RUCH(I)=RCL+ADML(I)*(RCT-RCL)                                         002525
00704   333*          RAF(I)=RUCH(I)/TUE(I)                                                 002532
00705   334*          IF (IDEBUG.NE.0)                                                      002536
00705   335*         $WRITE(6,1004) ADML(I),PR,R(I),ROE(I),UE(I),THE(I),RO1,                002536
00705   336*         * V1,TW(I),TE(I),HCAW(I),GAM2,HSFT,TUL,TUE(I),TUT,TRNP,RETH(I)         002536
00705   337*         * ,RSRTM,RCL,RCT,RCTS,RSRTM,CF02,CH                                    002536
00741   338*      1004  FORMAT(1H0,108H ADML(I),PR,R(I),ROE(I),UE(I),THE(I),RO1,          002603
00741   339*         $V1,TW(I),TE(I),HCAW(I),GAM2,HSFT,TUL,TUE,TUT,TRNP,RETH(I) /           002608
00741   340*         $ 2X,32HRSRTM,RCL,RCT,RCTS,RSRTM,CF02,CH/                              002608
00741   341*         $8(1X,E15.6))                                                          002608
00742   342*          RUFSMT(I)=RSRL+ADML(I)*(RSRT-RSRL)                                    002608
00743   343*          HSF(I)=HSFL+ADML(I)*(HSFT-HSFL)                                       002608
00744   344*          HR(I)=HE(I)+RECOV    *UE(I)**2/2./BTU/GC                              002606
00745   345*          IF (IDEBUG.NE.0)                                                      002613
00745   346*         *WRITE (6,1003) I,ITER,ADML(I),TUE(I),RUCH(I),ROE(I),UE(I),            002623
00745   347*         1           HE(I),TE(I),VISE(I),ENTR(I),DTF(I),DPF(I),THE(I),PHI(I)    002623
00767   348*      1003 FORMAT(/10X,95HI,ITER,ADML(I),TUE,RUCH(I),ROE(I),UE(I),HE(I),TE(I),VIS 002623
00767   349*         *,VISE(I),ENTR(I),DTF(I),DPF(I),THE(I),PHI(I)/5X,2I5,1P6E15.6/15X,      002653
00767   350*         * 1P7E13.6)                                                            002653
00767   351*      C *** INTEGRAL MOMENTUM AND ENERGY EQNS                                   002653
00770   352*          HT2=HE(I)+UE(I)**2/2./GC/BTU                                          002653
00771   353*          DTF(I)=R(I)*UE(I)*TUE(I)*(1.+RAF(I)*BP(I)*CMM(1))                     002653
00772   354*          DPF(I)=R(I)*RUCH(I)*(HR(I)-HW(I)+(HT2-HW(I))*BP(I)*CMM(1))            002663
00772   355*      C                                                                         002674
00773   356*          IF(ITER.EQ.1)  GO TO 161                                              002674
00773   357*      C                                                                         002706
00775   358*          RATT=ABS((TUE(I)-TUEOLD)/TUE(I))                                      002706
00776   359*          RATR=ABS((RUCH(I)-RUCHO)/RUCH(I))                                     002711
00777   360*          IF(RATT.LT..001.AND.RATR.LT..001)  GO TO 162                          002716
01001   361*          GO TO 160                                                             002723
01002   362*      161 CONTINUE                                                              002737
01003   363*          LTTSTR = LTT                                                          002741
01004   364*          STORE(1) = HE(I)                                                      002741
01005   365*          STORE(2) = ENTR(I)                                                    002743
01006   366*          STORE(3) = TE(I)                                                      002745
01007   367*          STORE(4) = VISE(I)                                                    002747
01010   364*          STORE(5) = ROE(I)                                                     002751
01011   369*          STORE(6) = UE(I)                                                      002753
01012   370*          STORE(7) = HCAW(I)                                                    002755
01013   371*          STORE(9) = URE(I)                                                     002757
01014   372*          STORE(10) = BETP(I)                                                   002761
01015   373*          STORE(11) = THE(I)                                                    002763
01016   374*          STORE(12) = PHI(I)                                                    002765
01017   375*          STORE(13) = RETH(I)                                                   002767
                                                                                          002771
```

```
01020   376*          STORE(14) = REPH(I)                                                  002773
01021   377*          STORE(15) = HR(I)                                                    002775
01022   378*          STORE(16) = ADML(I)                                                  002777
01023   379*          STORE(17) = RUCH(I)                                                  003001
01024   380*          STORE(18) = RAF(I)                                                   003003
01025   381*          STORE(19) = RUFSMT(I)                                                003005
01026   382*          STORE(21) = HSF(I)                                                   003007
01027   383*          STORE(22) = DTF(I)                                                   003011
01030   384*          STORE(23) = DPF(I)                                                   003013
01031   385*          STORE(24) = TUE(I)                                                   003015
01031   386*      C                                                                        003015
01032   387*        160 CONTINUE                                                           003015
01034   388*          IF (RATT - .05) 68, 67, 67                                           003021
01034   389*      C   ***********                                                          003021
01037   390*         67 CALL MEITEX(I,1,DTF(I),DPF(I),RSRL,LTTSTR,STORE)                   003021
01037   391*      C   ***********                                                          003026
01040   392*          GO TO 71                                                             003026
01041   393*         68 IF (RATR - .05) 71, 69, 69                                         003043
01044   394*         69 DPF(I) = DPF(I-1)                                                  003045
01044   395*      C   ***********                                                          003051
01045   396*          CALL MEITEX(I,2,DTF(I),DPF(I),RSRL,LTTSTR,STORE)                     003051
01045   397*      C   ***********                                                          003053
01046   398*         71 CONTINUE                                                           003053
01047   399*          IF (IDEBUG.EQ.0) GO TO 162                                           003071
01051   400*          CALL LCOUNT(5)                                                       003071
01052   401*          WRITE(6,150)  I,RATT,RATR                                            003072
01057   402*        150 FORMAT(//38X,56H COMPUTATION OF MEIT EQUATIONS DID NOT CONVERGE AT 003075
01057   403*         * POINT,I4/                                                           003106
01057   404*         * 55X,18H(TUE-TUEOLD)/TUE =,1PE12.5/                                  003106
01057   405*         * 55X,19H(RUCH-RUCHO)/RUCH =,1PE12.5)                                 003106
01060   406*        162 CONTINUE                                                           003106
01060   407*      C *** DETERMINE TRANSITION PARAMETERS                                    003106
01061   408*        170 IF (LTT.NE.0) GO TO 175                                            003106
01063   409*          LTT=2                                                                003107
01064   410*          IF (IBRUPT.EQ.1) LTT = 3                                             003111
01066   411*          PERSH = 2.                                                           003120
01067   412*          TRNP = (TUT-TUL)*RETH(I)**PERSH/ROE(I)/UE(I)                         003122
01070   413*          IF (INXT.NE.I) STRAN = S(I)-RATIO*(S(I)-S(INXT))                     003137
01072   414*          IF(IDEBUG.EQ.1)                                                      003151
01072   415*         $WRITE(6,1007) I,INXT,LTT,RATIO,STRAN                                 003151
01102   416*       1007 FORMAT(1H0,22HI,INXT,LTT,RATIO,STRAN /1X,3I3,2X,1P2E12.5)          003167
01102   417*      C                  **********                                            003167
01103   418*        175 IF(LTT.LE.1) CALL TRANS(I,INXT,RATIO)                            003167
01103   419*      C                  **********                                            003167
01105   420*          IF (LTT.EQ.0) GO TO 65                                               003177
01107   421*          IF(KLIT.EQ.2)  GO TO 176                                             003201
01111   422*          IF(NOSTRN.NE.1) GO TO 176                                            003204
01113   423*          GO TO 54                                                             003207
01114   424*        176 CONTINUE                                                           003211
01115   425*          I=I+1                                                                003211
01116   426*          IF (I.LE.NTT) GO TO 65                                               003213
01116   427*      C                                                                        003213
01116   428*      C *** END OF LOOP                                                        003213
01116   429*      C                                                                        003213
01120   430*          DO 180 I=1,NS                                                        003223
01123   431*          ISUB = IPT(I)                                                        003223
01124   432*          RUCHSP(I) = RUCH(ISUB)                                               003225
```

```
01125    435*          HRSP(I) = HR(ISUB)                                  003227
01126    434*          PRESP(I) = PE(ISUB)                                 003231
01127    435*      180 CONTINUZ                                            003234
01131    436*          RETURN                                              003234
01132    437*          END                                                 003265
```

```
00101      1*          SUBROUTINE REITEX(I,ITR,DTF,DPF,RSRL,LTTSTR,STORE)
00103      2*          DIMENSION STORE(25)
00104      3*          INCLUDE COMON
00104      4*    C-------
00111      5*          GO TO (100, 200), ITR
00112      6*      100 CONTINUE
00113      7*          LTT = LTTSTR                                          000010
00114      8*          HE(I) = STORE(1)                                      000010
00115      9*          ENTR(I) = STORE(2)                                    000012
00116     10*          TE(I) = STORE(3)                                      000014
00117     11*          VISE(I) = STORE(4)                                    000016
00120     12*          ROE(I) = STORE(5)                                     000021
00121     13*          UE(I) = STORE(6)                                      000022
00122     14*          MCAM(I) = STORE(7)                                    000024
00123     15*          URE(I) = STORE(9)                                     000026
00124     16*          BETP(I) = STORE(10)                                   000030
00125     17*          THE(I) = STORE(11)                                    000032
00126     18*          PHI(I) = STORE(12)                                    000034
00127     19*          RETH(I) = STORE(13)                                   000036
00130     20*          REPH(I) = STORE(14)                                   000040
00131     21*          HR(I) = STORE(15)                                     000042
00132     22*          ADML(I) = STORE(16)                                   000044
                                                                           000046
```

```
00133    23*          RUCH(I) = STORE(17)                                                    000050
00134    24*          RAF(I) = STORE(18)                                                     000052
00135    25*          RUFSAT(I) = STORE(19)                                                  000054
00136    26*          HSF(I) = STORE(21)                                                     000056
00137    27*          DTF = STORE(22)                                                        000060
00140    28*          DPF = STORE(23)                                                        000062
00141    29*          TUE(I) = STORE(24)                                                     000064
00142    30*          GO TO 300                                                              000066
00143    31*     200  CONTINUE                                                             000070
00144    32*          PHI (I) = (ROE(I-1)*UE(I-1)*PHI(I-1)*R(I-1)*(HT2 - HW(I-1))           000070
00144    33*         $          + DPF*(S(I) - S(I-1)))/(ROE(I)*UE(I)*R(I)*(HT2 - HW(I)))    000070
00145    34*          IF (PHI(I) .LT. 0.) PHI(I) = PHI(I-1)                                  000114
00147    35*          REPH(I) = URE(I)*PHI(I)                                                000122
00150    36*          RCL = 0.                                                               000126
00151    37*          IF (LTT .EQ. 3) GO TO 10                                               000127
00153    38*          CALL SR1(I,C1,C2)                                                      000132
00154    39*          RCL = C2*VISE(I)/PHI(I)                                                000137
00155    40*          RSRLA=RSRL**2                                                          000144
00156    41*          RCL=RCL*RSRLA                                                          000147
00157    42*          RCT=RCL                                                                000151
00160    43*          RSRT=RSRL                                                              000152
00161    44*          IF (LTT .EQ. 1) GO TO 20                                               000154
00163    45*       10 CALL SR2 (I, CFO2, CH, RSHTM, RSRTH)                                   000160
00164    46*          RCTS = ROE(I)*UE(I)*CH                                                 000166
00165    47*          RCT = RSRTH*RCTS                                                       000173
00166    48*          IF (LTT.LT.3.AND.RCT.LT.RCL) RCT = RCL                                 000175
00170    49*          RSRT=RCT/RCTS                                                          000215
00171    50*       20 CONTINUE                                                               000221
00172    51*          RUCH(I) = RCL + ADAL(I)*(RCT - RCL)                                    000221
00173    52*          RAF(I) = RUCH(I)/TUE(I)                                                000226
00174    53*          RUFSAT(I) = RSRL + ADAL(I)*(RSRT - RSRL)                               000230
00175    54*          MAT = MATL(I)                                                          000235
00176    55*          DPF=RUCH(I)*((HR(I)-HW(I))/(HE(1)-HW(I))+BP(I)*CMH(1))                 000237
00176    56*         $      *R(I) * (HT2 - HW(I))                                           000237
00177    57*     300  CONTINUE                                                             000256
00200    58*          RCTURN                                                                 000256
00201    59*          END                                                                    000426
```

```
00101     1*      SUBROUTINE OUTPTI
00101     2*C
00101     3*C-----------------------------------------------------------------------
00101     4*C
00101     5*C     THIS ROUTINE WRITES THE RESULTS OF THE INVISCID FLOW SOLUTION
00101     6*C
00101     7*C-----------------------------------------------------------------------
00101     8*C
00103     9*      INCLUDE COMON
00110    10*      INCLUDE COMUNT
00110    11*C             WRITE TITLE AND HEADING
00110    12*C
00112    13*      CALL LCOUNT(-3)
00113    14*      WRITE(6,20040)
00115    15*20040 FORMAT(/50X,25HGENERAL INPUT INFORMATION/50X,25(1H*))                  000002
00116    16*      CALL LCOUNT(6)                                                        000007
00117    17*      WRITE(6,20060)                                                        000007
00121    18*20060 FORMAT(/T3,4HBODY,T11,5HINTEG,T19,4HMATL,T26,6HSTREAM,T36,5HAXIAL,   000012
     1  19*     *T45,6HRADIAL,T56,4HBODY,T68,16HNORMALIZED,T81,4HWALL,T89,             000017
     1  20*     *7HSURFACE,T103,28H---EDGE CONDITION---,/T3,2HPT,T6,2HNO,T11,2HPT,     000017
     1  21*     *T14,2HNO,T20,2HNO,T26,6HLENGTH,T36,6HLENGTH,T45,6HLENGTH,T56,         000017
     1  22*     *5HANGLE,T64,13HABLATION RATE,T81,4HTEMP,T88,9HROUGHNESS,T101,         000017
     1  23*     *8HPRESSURE,T112,8HENTHALPY,T123,8HVELOCITY/T27,4HINCH,T37,4HINCH,     000017
     1  24*     *T46,4HINCH,                                                          000017
     1  25*     *T56,3HDEG,T68,3HDEG R,T91,3HMIL,T103,3HATM,T112,7HBTU/LBM,T124,       000017
     1  26*     *6HFT/SEC/T4,3H(J),T12,3H(I),T18,6H(MATL),T27,3H(S),T37,3H(Z),T46,     000017
     1  27*     *3H(R),T55,7H(THETB),T67,6H(BPSP),T81,4H(TW),T89,8H(RUFMIL),T103,      000017
     1  28*     *4H(PE),T114,4H(HE),T125,4H(UE)/)                                     000017
     1  29*20121 FORMAT(1X,I4,T11,I3,T20,I2,T25,F7.2,T35,F8.3,T44,F8.3,T54,F8.3,       000017
     1  30*     *T64,F8.3,T79,F7.2,T89,F8.3,T101,F8.2,T111,F9.2,T123,F8.2)            000017
     1  31*      J = 1                                                                000017
     1  32*      DO 100 I=1,NTT                                                       000017
     1  33*      IF (LCT.GT.1) GO TO 300                                              000026
     1  34*      CALL LCOUNT(-6)                                                      000026
     1  35*      WRITE(6,20060)                                                       000032
     1  36*  300 IF (IPT(J).NE.I) GO TO 400                                          000035
     1  37*      SINCH=S(I)*FT                                                        000043
     1  38*      ZINCH=(Z(I)+ZSP(1))*FT                                               000046
     1  39*      RINCH=R(I)*FT                                                        000051
     1  40*      THERAD = THETB(I)*RAD                                                000055
     1  41*      RUFMIL=RUF(I)*FTMIL                                                  000060
     1  42*C                                                                         000063
     1  43*      CALL LCOUNT(1)                                                       000063
     1  44*      WRITE(6,20121) J,I,MATL(I),SINCH,ZINCH,RINCH,THERAD,BPSP(I),TW(I),   000066
     1  45*     *RUFMIL,PE(I),HE(I),UE(I)                                             000071
     1  46*      J = J+1                                                              000071
     1  47*      GO TO 100                                                            000118
     1  48*  400 IF(IABS(IPRNT).NE.2) GO TO 100                                      000116
     1  49*      SINCH=S(I)*FT                                                        000120
     1  50*      ZINCH=(Z(I)+ZSP(1))*FT                                               000122
                                                                                     000125
```

```
00171     51*          RINCH=R(I)*FT                                                    000151
00172     52*          THERAD = THETB(I)*RAD                                            000154
00173     53*          RUFAIL=RUF(I)*FTAIL                                              000157
00173     54*     C                                                                     000157
00174     55*          CALL LCOUNT(1)                                                   000157
00175     56*          WRITE(6,20121) J,I,MATL(I),BINCH,ZINCH,RINCH,THERAD,BPSP(I),TW(I),  000162
00175     57*         *RUFAIL,PE(I),HE(I),UE(I)                                         000165
00214     58*      100 CONTINUE                                                         000165
00214     59*     C                                                                     000171
00216     60*          RETURN                                                           000171
00217     61*          END                                                              000171
                                                                                       000214
```

```
00101     1*          SUBROUTINE OUTPTV
00101     2*    C
00101     3*    C-----------------------------------------------------------------------
00101     4*    C
00101     5*    C     THIS ROUTINE WRITES THE RESULTS OF THE VISCOUS FLOW SOLUTION
00101     6*    C
00101     7*    C-----------------------------------------------------------------------
00101     8*    C
00103     9*          INCLUDE CORON
00110    10*          INCLUDE CORUNT
00110    11*    C
00110    12*    C              EDGE PROPERTIES OUTPUT
00110    13*    C
00112    14*          CALL LCOUNT(-3)
00113    15*          WRITE(6,20020)
00115    16*    20020 FORMAT(/48X,30HVISCOUS FLOW - EDGE PROPERTIES/48X,30(1H*))                  000002
00115    17*    C                                                                               000007
00116    18*          CALL LCOUNT(6)                                                            000007
00117    19*          WRITE(6,20040)                                                            000007
00121    20*    20040 FORMAT(/5X,4HBODY,3X,5HINTEG,5X,6HSTREAM,6X,8HVELOCITY,8X,4HMACH,         000012
00121    21*         * 6X,8HENTHALPY,4X,11HTEMPERATURE,4X,7HDENSITY,6X,9HVISCOSITY,            000017
00121    22*         * 9X,4HUNIT/                                                              000017
00121    23*         * 4X,5HPT NO,3X,5HPT NO,5X,6HLENGTH,23X,2HNO,64X,5HRE NO/                 000017
00121    24*         * 23X,4HINCH,8X,6HFT/SEC,20X,7HBTU/LBM,7X,5HDEG R,7X,7HLBM/FT3,           000017
00121    25*         * 5X,10HLBM/FT-SEC, 9X,4H1/FT/                                            000017
00121    26*         * 5X,3H(J),5X,3H(I),8X,3H(S),9X,4H(UE),9X,6H(HCAM),8X,4H(HE),9X,          000017
00121    27*         * 4H(TE),8X,5H(ROE),8X,6H(VISE),10X,5H(URE)/)                             000017
00121    28*    C                                                                               000017
00122    29*          J = 1                                                                     000017
00123    30*          DO 100 I=1,NTT                                                            000017
00126    31*          IF (LCT.GT.1) GO TO 110                                                   000026
00126    32*    C                                                                               000026
00130    33*          CALL LCOUNT(-6)                                                           000026
00131    34*          WRITE (6,20040)                                                           000032
00133    35*      110 IF(IPT(J).NE.I) GO TO 120                                                 000035
00135    36*          SINCH=S(I)*FT                                                             000043
00135    37*    C                                                                               000046
00136    38*          CALL LCOUNT(1)                                                            000046
00137    39*          WRITE(6,20121) J,I,SINCH,UE(I),HCAM(I),HE(I),TE(I),ROE(I),                000051
00137    40*         * VISE(I),URE(I)                                                          000054
00153    41*    20121 FORMAT(1X,I6,I8,F13.4,F13.1,F14.4,F13.1,F13.1,1PE13.3,1PE14.3,           000054
00153    42*         * 1PE16.3)                                                                000073
00154    43*          J=J+1                                                                     000073
00158    44*          GO TO 100                                                                 000073
00156    45*      120 IF(IABS(IPRNT).NE.2) GO TO 100                                            000076
00160    46*          SINCH=S(I)*FT                                                             000100
00160    47*    C                                                                               000102
                                                                                               000102
```

```
00161    48*          CALL LCOUNT(1)                                                    000105
00162    49*          WRITE(6,20120) I,SINCH,UE(I),HCAM(I),HE(I),TE(I),ROE(I),VISE(I),  000110
00162    50*         * URE(I)                                                           000110
00175    51*    20120 FORMAT(1X,I14,F13.4,F13.1,F14.4,F13.1,F13.1,1PE13.3,1PE14.3,      000130
00175    52*         * 1PE16.3)                                                         000130
00176    53*      100 CONTINUE                                                         000130
00176    54*    C                                                                      000130
00176    55*    C     WALL AND B. L. RECOVERY PROPERTIES OUTPUT                        000130
00176    56*    C                                                                      000130
00200    57*          CALL LCOUNT(-3)                                                  000130
00201    58*          WRITE(6,40120)                                                   000133
00203    59*    40120 FORMAT(/39X,49HVISCOUS FLOW - WALL AND B. L. RECOVERY PROPERTIES/ 000140
00203    60*         * 39X,49(1H*))                                                    000140
00233    61*    C                                                                      000140
00204    62*          CALL LCOUNT(6)                                                   000140
00205    63*          WRITE(6,40140)                                                   000143
00207    64*    40140 FORMAT(/4X,4HBODY,4X,5HINTEG,4X,6HSTREAM,8X,4HWALL,9X,4HWALL,9X,  000150
00207    65*         * 4HWALL,8X,4HWALL,7X,8HRECOVERY,4X,8HRECOVERY,3X,11HSENSBL CONV,   000150
00207    66*         * 6X,4HCF/2/                                                       000150
00207    67*         * 3X,5HPT NO,4X,5HPT NO,4X,6HLENGTH,4X,11HTEMPERATURE,4X,          000150
00207    68*         * 8HENTHALPY,5X,7HDENSITY,5X,9HVISCOSITY,4X,8HENTHALPY,5X,         000150
```

```
00207     69*          * 6HFACTOR,5X,9HHEAT FLUX/                                                    000150
00207     70*          * 22X,4HINCH,8X,5HDEG R,8X,7HBTU/LBM,5X,7HLBM/FT3,4X,10HLBM/FT-SEC,           000150
00207     71*          * 9X,7HBTU/LBM,15X,11HBTU/FT2-SEC/                                            000150
00207     72*          * 4X,3H(J),6X,3H(I),7X,3H(S),9X,4H(TW),9X,4H(HW),8X,5H(ROW),7X,               000150
00207     73*          * 6H(VISW),8X,4H(HR),7X,7H(RECOV)/)                                           000150
00207     74*     C                                                                                  000150
00210     75*          CF02 = 1.E30                                                                  000150
00211     76*          J = 1                                                                         000150
00212     77*          DO 400 I=1,NTT                                                                000152
00215     78*          IF (LCT.GT.1) GO TO 410                                                       000161
00215     79*     C                                                                                  000161
00217     80*          CALL LCOUNT(-6)                                                               000161
00220     81*          WRITE(6,40140)                                                                000165
00222     82*       410 CONTINUE                                                                     000170
00223     83*          SINCH = S(I)*FT                                                               000176
00224     84*          RECOV = SQRT(PR)*ADML(I)*(PR**0.3333-SQRT(PR))                                000201
00225     85*          QFLUX = RUCH(I)*(HR(I)-HW(I))                                                 000204
00226     86*          IF (I.NE.1) CF02 = TUE(I)/ROE(I)/UE(I)                                        000215
00230     87*          IF (IPT(J).NE.I) GO TO 420                                                    000222
00230     88*     C                                                                                  000231
00232     89*          CALL LCOUNT(1)                                                                000231
00233     90*          WRITE(6,40100) J,I,SINCH,TW(I),HW(I),ROW(I),VISW(I),HR(I),RECOV,              000235
00233     91*         * QFLUX,CF02                                                                   000240
00250     92*     40100 FORMAT(1X,I5,I9,F12.4,F12.1,F14.1,1PE14.3,1PE13.3,0PF11.1,F12.4,             000240
00250     93*         * 1PE14.3,1PE14.3)                                                             000260
00251     94*          J = J+1                                                                       000260
00252     95*          GO TO 400                                                                     000260
00253     96*       420 IF (IABS(IPRNT).NE.2) GO TO 400                                              000263
00253     97*     C                                                                                  000265
00255     98*          CALL LCOUNT(1)                                                                000265
00256     99*          WRITE(6,40200) I,SINCH,TW(I),HW(I),ROW(I),VISW(I),HR(I),RECOV,                000267
00256    100*         * QFLUX,CF02                                                                   000272
00272    101*     40200 FORMAT(1X,I4,F12.4,F12.1,F14.1,1PE14.3,1PE13.3,0PF11.1,F12.4,               000272
00272    102*         * 1PE14.3,1PE14.3)                                                             000313
00273    103*       400 CONTINUE                                                                     000313
00273    104*     C                                                                                  000313
00273    105*     C              BOUNDARY LAYER OUTPUT                                               000313
00273    106*     C                                                                                  000313
00275    107*          CALL LCOUNT(-3)                                                               000313
00276    108*          WRITE(6,30020)                                                                000313
00300    109*     30020 FORMAT(/43X,38HVISCOUS FLOW - BOUNDARY LAYER SOLUTION/                       000316
00300    110*         * 43X,38(1H*))                                                                 000323
00300    111*     C                                                                                  000323
00301    112*          CALL LCOUNT(6)                                                                000323
00302    113*          WRITE(6,30040)                                                                000323
00304    114*     30040 FORMAT(/4X,4HBODY,8X,5HINTEG,4X,6HSTREAM,4X,8HMOMENTUM,4X,                   000326
00304    115*         * 6HENERGY,6X,5HSHAPE,2X,9HMOM THICK,2X,12HENERGY THICK,2X,                    000333
00304    116*         *10HHEAT TRANS,3X,8HREYNOLDS,2X,6HINTER-,T119,10HHEAT TRANS/                   000333
00304    117*         * 3X,5HPT NO,3X,5HPT NO,4X,6HLENGTH,3X,9HTHICKNESS,2X,9HTHICKNESS,            000333
00304    118*         * 4X,6HFACTOR,4X,5HRE NO,8X,5HRE NO,4X,11HCOEFFICIENT,3X,                     000333
00304    119*         *8HANAL FAC,1X,8HMITTENCY,T120,7HAUGMENT/                                      000333
00304    120*         * 21X,4HINCH,8X,3HMIL,8X,3HMIL,38X,11HLBM/FT2-SEC/                            000333
00304    121*         * 4X,3H(J),5X,3H(I),7X,3H(S),7X,5H(THE),6X,5H(PHI),6X,5H(HSF),4X,             000333
00304    122*         * 6H(RETH),6X,6H(REPH),7X,6H(RUCH),7X,5H(RAF),3X,6H(ADML),6X,                 000333
00304    123*         *T120,8H(RUFSMT))                                                              000333
00304    124*     C                                                                                  000333
00305    125*          J = 1                                                                         000333
                                                                                                    000333
```

```
00306    126*          DO 300  I=1,NTT                                                  000342
00311    127*          IF (LCT.GT.1) GO TO 330                                          000342
00311    128*    C                                                                      000342
00313    129*          CALL LCOUNT(-6)                                                  000342
00314    130*          WRITE (6,30040)                                                  000346
00316    131*      330 IF(IPT(J).NE.I) GO TO 350                                        000351
00320    132*          SINCH=S(I)*FT                                                    000357
00321    133*          THEMIL = THE(I)*FTMIL                                            000362
00322    134*          PHIMIL = PHI(I)*FTMIL                                            000365
00322    135*    C                                                                      000370
00323    136*          CALL LCOUNT(1)                                                   000370
00324    137*          IF (NREYCR.EQ.5.OR.NREYCR.EQ.6) GO TO 370                        000373
00326    138*          WRITE(6,30221) J,I,SINCH,THEMIL,PHIMIL,HSF(I),RETH(I),REPH(I),   000376
00326    139*         *RUCH(I),RAF(I),ADML(I),RUFSMT(I)                                 000412
00344    140*    30221 FORMAT(1X,I5,I8,F12.4,F11.3,F11.3,F10.3,1PE12.5,1PE12.5,1PE13.5, 000412
00344    141*         *0PF11.4,F8.2,F13.3,T119,F8.3)                                    000433
00345    142*          J = J+1                                                          000433
00346    143*          GO TO 300                                                        000433
00347    144*      370 WRITE(6,30221) J,I,SINCH,THEMIL,PHIMIL,HSF(I),RETH(I),REPH(I),   000436
00347    145*         * RUCH(I),RAF(I),ADML(I),TP(I)                                    000440
00365    146*          J = J+1                                                          000460
00366    147*          GO TO 300                                                        000460
00367    148*      350 IF(IABS(IPRNT).NE.2) GO TO 300                                   000463
00371    149*          SINCH=S(I)*FT                                                    000463
00372    150*          THEMIL = THE(I)*FTMIL                                            000467
00373    151*          PHIMIL = PHI(I)*FTMIL                                            000472
00378    152*    C                                                                      000475
00374    153*          CALL LCOUNT(1)                                                   000475
00375    154*          IF (NREYCR.EQ.5.OR.NREYCR.EQ.6) GO TO 390                        000500
00377    155*          WRITE(6,30220) I,SINCH,THEMIL,PHIMIL,HSF(I),RETH(I),REPH(I),     000503
00377    156*         *RUCH(I),RAF(I),ADML(I),RUFSMT(I)                                 000517
00414    157*    30220 FORMAT(1X,I13,F12.4,F11.3,F11.3,F10.3,1PE12.5,1PE12.5,1PE13.5,  000517
00414    158*         *0PF11.4,F8.2,F13.3,T119,F8.3)                                    000537
00415    159*          GO TO 300                                                        000537
00416    160*      390 WRITE(6,30220) I,SINCH,THEMIL,PHIMIL,HSF(I),RETH(I),REPH(I),     000537
00416    161*         * RUCH(I),RAF(I),ADML(I),TP(I)                                    000541
00433    162*      300 CONTINUE                                                         000541
00433    163*    C                                                                      000562
00435    164*          RETURN                                                           000562
00436    165*          END                                                              000562
                                                                                       000601
```

```
00101     1*          SUBROUTINE QADRYC(J,X1,X2,X3,X,Y1,Y2,Y3,Y)
00101     2*     C
00101     3*     C-------------------------------------------------------------------
00101     4*     C
00101     5*     C     THIS ROUTINE PERFORMS A THREE POINT QUADRITIC CURVE FIT
00101     6*     C
00101     7*     C-------------------------------------------------------------------
00101     8*     C
00103     9*          A=Y2
00104    10*          D=(X3-X2)*(X2-X1)*(X3-X1)                                          000001
00105    11*          B=((Y3-Y2)*((X2-X1)**2)+(Y2-Y1)*((X3-X2)**2))/D                    000018
00106    12*          C=((Y3-Y2)*(X2-X1)-(Y2-Y1)*(X3-X2))/D                              000031
00107    13*          IF (J.GT.1) GO TO 10                                               000040
00111    14*          Y=A+B*(X-X2)+C*((X-X2)**2)                                         000044
00112    15*          RETURN                                                             000055
00113    16*       10 Y=B+2.0*C*(X-X2)                                                   000061
00114    17*          RETURN                                                             000067
00115    18*          END                                                                000113
```

```
00101    1*          SUBROUTINE RUFNES(I,RIF)                                    000003
00103    2*          INCLUDE COMON                                               000004
00110    3*          INCLUDE COMUNT                                              000004
00112    4*          MAT = MATL(I)                                               000015
00113    5*          RUFT=0.                                                     000021
00114    6*          CALL TBLP(S(I),SP,EFFKI,EFFK,NS)                            000026
00114    7*    C     SCALLOPE ROUGHNESS MODEL  ***************************************** 000045
00115    8*          IF (RUF1(MAT).LE.1.E-7) GO TO 8                             000054
00117    9*          IF(I.GT.KSHOLD) GO TO 10                                    000074
00121   10*          RUFS=RUF1(MAT)/(PEPI(I)*PI2*ATM)**0.77                      000103
00122   11*          IF (RUFS.GT.RUFMAX(MAT)) RUFS = RUFMAX(MAT)                 000110
00124   12*          IF(THETB(I).GT.0.5.OR.THETB(NTT).GE.0.5) GO TO 9            000112
00126   13*          RAT=(RUFS-RUFL(MAT))/(0.5-THETB(I))                         000115
00127   14*          RUFS=RUFL(MAT)+RAT*(THETB(I)-THETB(NTT))                    000124
00130   15*          GO TO 9                                                     000136
00131   16*        8 RUFS=RUFMAX(MAT)                                            000163
00132   17*        9 RUFT=RUFL(MAT)+ADML(I)*(RUFS-RUFL(MAT))
00133   18*       10 RIF=AMAX1(RUFL(MAT),EFFKI,RUFT)
00134   19*          RETURN
00135   20*          END
```

```
00101     1*          SUBROUTINE SR1(I,C1,C2)
00103     2*          INCLUDE COMON
00110     3*          COMMON/PRCAL/PRL,PRT
00110     4*      C *** LAMINAR SHEAR AND HEAT TRANSFER FACTORS
00111     5*          MAT = MATL(I)
00112     6*          CB=2.*BLS(MAT)*BP(I)*RAF(I)*CMH(1)                                                    000002
00113     7*          C1=0.245                                                                              000011
00114     8*          IF (CB.GT.0.001) C1=C1*ALOG(1.0+CB)/CB                                                000014
00116     9*          IF(BETP(I).GT.0.) C1=C1*(1.0+3.0*BETP(I))**0.3333                                     000031
00120    10*          RECOV=SQRT(PR)                                                                        000046
00121    11*          HREF=0.42*HE(I)+0.58*HW(I)+0.19*RECOV*(HT2-HE(I))                                     000052
00122    12*          CALL ESTATE(1,PE(I),HREF,EREF,TREF,RMW,PRL,RORF,AA)                                   000065
00123    13*          VISR=EREF                                                                             000102
00124    14*          HT2=HE(I)+UE(I)**2/2./32.174/778.158                                                  000104
00125    15*          REFF=RORF*VISR*(HT2-HW(I))/(ROE(I)*VISE(I)*(HR(I)-HW(I)))                             000113
00126    16*          IF(REFF.LE.0.)  REFF=1.                                                               000125
00130    17*          CB=2.*BLH(MAT)*BP(I)*CMH(1)                                                           000132
00131    18*          C2=.220*REFF/PR**1.33333                                                              000140
00132    19*          IF(BETP(I).GT.0.)  C2=C2*(1.+4.*BETP(I))**0.1667                                      000150
00134    20*          IF(CB.GT..001)  C2=C2*ALOG(1.+CB)/CB                                                  000165
00136    21*          RETURN                                                                                000202
00137    22*          END                                                                                   000235
```

```
00101     1*          SUBROUTINE SR2 (I, C3, C5, RSRTM, RSRTH)
00103     2*          INCLUDE COMON
00110     3*          COMMON/PRCAL/PRL,PRT
00110     4*     C *** TURBULENT SHEAR AND HEAT TRANSFER FACTORS
00111     5*          RECOV=PR**0.3333
00112     6*          HREF=0.55*HE(I)+0.45*HW(I)+0.19*RECOV*(HT2-HE(I))                    000005
00113     7*          CALL ESTATE(1,PE(I),HREF,EREF,TREF,RMW,PRT,RORF,AA)                  000020
00114     8*          VISR=EREF                                                            000035
00115     9*          REFF=RORF/ROE(I)*(VISR/VISE(I))**.25                                 000037
00116    10*          MAT = MATL(I)                                                        000051
00117    11*          CB=2.*BTS(MAT)*BP(I)*RAF(I)*CMH(1)                                   000053
00120    12*          BC=1.0                                                               000062
00121    13*          IF (CB.GT.0.001) BC=ALOG(1.0+CB)/CB                                  000065
00123    14*          C4=1.                                                                000101
00124    15*          IF(BETP(I).GT.0.)  C4=(1.+3.*BETP(I))**0.3333                        000103
00126    16*          C3 = .245*C4/RETH(I)                                                 000117
90127    17*          IF (RETH(I).GT.2.) C3 = C3+.0123*RETH(I)/(100.+RETH(I))/             000125
```

```
00127     18*       $ ALOG10(RETH(I))**1.6                                                                  000123
00131     19*        C3=C3*REFF*BC                                                                          000153
00132     20*        CB=2.*BTH(MAT)*BP(I)*CMH(1)                                                            000157
00133     21*        BC=1.0                                                                                 000165
00134     22*        IF (CB.GT.0.001) BC=ALOG(1.0+CB)/CB                                                    000167
00136     23*        C6=1.                                                                                  000203
00137     24*        IF(BETP(I).GT.0.)  C6=(1.+4.*BETP(I))**0.1667                                          000205
00141     25*        C5 = .22/PR**1.3333*C6/REPH(I)                                                         000221
00142     26*        IF (REPH(I).GT.2.) C5 = C5+.0123/SQRT(PR)*REPH(I)/(100.+REPH(I))/                      000232
00142     27*       $ ALOG10(REPH(I))**1.6                                                                  000232
00144     28*        C5=C5*REFF*BC                                                                          000266
00144     29*    C            ROUGHNESS INFLUENCE COEFFICIENTS -                                          000266
00145     30*        RSRTM = 1.                                                                             000272
00146     31*        RSRTH = 1.                                                                             000274
00147     32*        IF (RUF(I) .LE. 0.) GO TO 10                                                           000275
00151     33*        ROVIS = VISE (I) / VISW (I) * SQRT (ROW (I) / ROE (I))                                 000300
00152     34*        SLOPE = .09*RUF(I)/THE(I) + .53*(1. - EXP(-RUF(I)/THE(I))) + 1.                        000513
00153     35*        ABSIS = ALOG10(URE(I)*RUF(I)*ROVIS   *SQRT(C3)/15.5)                                   000321
00154     36*        FUNCT = ABSIS - 1.5*(EXP(-ABSIS) - 1.)                                                 000347
00155     37*        RSRTM = 1. + AMAX1( .5*SLOPE*FUNCT , 0. )                                              000357
00156     38*        RSRTH = 1. + AMAX1( .3*SLOPE*FUNCT , 0. )                                              000378
00157     39*      10 CONTINUE                                                                              000402
00160     40*        RETURN                                                                                 000402
00161     41*        END                                                                                    000445
```

```
00101      1*          SUBROUTINE TBLP(X,XT,Y,YT,N)                                    000006
00101      2*    C                                                                     000006
00101      3*    C-------------------------------------------------------------------- 000006
00101      4*    C                                                                     000006
00101      5*    C     THIS ROUTINE PERFORMS A TABLE LOOK-UP WITH LINEAR INTERPOLATION  000006
00101      6*    C     OR EXTRAPOLATION                                                000006
00101      7*    C                                                                     000006
00101      8*    C-------------------------------------------------------------------- 000006
00101      9*    C                                                                     000006
00101     10*    C     *** INPUT ***                                                   000006
00101     11*    C     X  = INDEPENDENT VARIABLE                                       000006
00101     12*    C     XT = INDEPENDENT FUNCTION ARRAY                                 000006
00101     13*    C     YT = DEPENDENT FUNCTION ARRAY                                   000006
00101     14*    C     N  = NUMBER OF ENTRIES IN FUNCTION ARRAY                        000006
00101     15*    C                                                                     000006
00101     16*    C     *** OUTPUT ***                                                  000006
00101     17*    C     Y  = DEPENDENT VARIABLE                                         000006
00101     18*    C                                                                     000006
00103     19*          DIMENSION XT(1),YT(1)                                           000006
00104     20*          IF (N.EQ.1) GO TO 30                                            000006
00106     21*          I = N                                                           000011
00107     22*          IF (X.GT.XT(N)) GO TO 20                                        000013
00111     23*          I = 1                                                           000021
00112     24*       10 I = I+1                                                         000024
00113     25*          IF (X.GT.XT(I)) GO TO 10                                        000026
00115     26*       20 Y = (X-XT(I))/(XT(I)-XT(I-1)+1.E-10)*(YT(I)-YT(I-1))+YT(I)      000035
00116     27*          RETURN                                                          000053
00116     28*    C                                                                     000053
00116     29*    C     FOR SINGLE ENTRY TABLE, USE THE VALUE YT(1)                     000053
00116     30*    C                                                                     000053
00117     31*       30 Y = YT(1)                                                       000057
00120     32*          RETURN                                                          000060
00121     33*          END                                                             000104
```

```
00101     1*          SUBROUTINE TRANS(I,INXT,RATIO)
00103     2*          INCLUDE COMON
00110     3*          INCLUDE COMUNT
00112     4*          INXT=I
00113     5*          GO TO (100,200,300,400,500,600,700),NREYCR                    000001
00113     6*    C *** ALL LAMINAR FLOW                                              000001
00114     7*      100 GO TO 1000                                                    000016
00114     8*    C *** RE THETA VS. EDGE MACH NO.                                    000016
00115     9*      200 CALL TBLP(HCAM(I),AR,REYCR,REM,NAM)                           000017
00116    10*          IF (RETH(I).LT.REYCR) GO TO 1000                            000030
00120    11*          RATIO=(RETH(I)-REYCR)/(RETH(I)-RETH(I-1))                   000034
00121    12*          INXT=I-1                                                    000042
00122    13*          GO TO 700                                                   000045
00122    14*    C *** RE STREAMLENGTH VS. EDGE MACH NO.                           000045
00123    15*      300 CALL TBLP(HCAM(I),AR,REYCR,REM,NAM)                         000047
00124    16*          IF(S(I)*URE(I).LT.REYCR) GO TO 1000                         000060
00126    17*          RATIO=(S(I)*URE(I)-REYCR)/(S(I)*URE(I)-S(I-1)*URE(I-1))     000065
00127    18*          INXT=I-1                                                    000075
00130    19*          GO TO 700                                                   000100
00130    20*    C *** AXIAL DISTANCE VS. ALTIOUDE                                 000100
00131    21*      400 ZTRAN=DLTRAN                                                000102
00132    22*          IF(Z(I).LT.ZTRAN) GO TO 1000                                000103
00134    23*          RATIO=(Z(I)-ZTRAN)/(Z(I)-Z(I-1))                            000107
00135    24*          INXT=I-1                                                    000115
00136    25*          GO TO 700                                                   000120
00136    26*    C *** PANT ROUGH WALL CRITERION                                   000120
00137    27*      500 IF (I.GT.KSHOLD) GO TO 600                                  000122
00141    28*          IF (NREYCR.EQ.6) GO TO 504                                  000125
00143    29*          PSY=TW(I)/TE(I)                                             000131
00144    30*          GO TO 506                                                   000134
00145    31*      504 PSY = .1*BP(I)+(.9+.1*ICARB)*(1.+.25*BP(I))*ROE(I)/ROW(I)   000136
00146    32*      506 TP(I)=RETH(I)*((RUF(I)/(PSY*THE(I)))**0.70)                 000156
00147    33*          IF (TP(I).LT.255.0) GO TO 1000                              000171
00151    34*          DO 510 J=1,I                                                000201
00154    35*          IF (TP(J).GE.215.0) GO TO 515                               000201
00156    36*      510 CONTINUE                                                    000210
00160    37*      515 I=J-1                                                       000210
00161    38*          IF (I.LT.4) I=4                                             000212
00163    39*          IF(I.GT.4)  RATIO=(215.-TP(I))/(TP(I+1)-TP(I))              000220
00165    40*          INXT=I+1                                                    000233
00166    41*          GO TO 700                                                   000236
00166    42*    C *** CONE TRANSITION                                             000236
00167    43*      600 IF(RETH(I).LT.275.0*EXP(0.13*HCAM(I))) GO TO 1000           000240
00171    44*          GO TO 700                                                   000252
00171    45*    C *** TRANSITION AT I=4                                           000252
00172    46*      700 LTT=0                                                       000254
00173    47*          IF (I.LT.KSHOLD) NOSTRN = 1                                 000254
00175    48*     1000 CONTINUE                                                    000263
00176    49*          RETURN                                                      000263
00177    50*          END                                                         000337
```

```
00101     1*        SUBROUTINE VORT1
00101     2*  C
00101     3*  C-----------------------------------------------------------------------
00101     4*  C
00101     5*  C     THIS ROUTINE COMPUTES THE COORDINATES AND ANGLES OF THE
00101     6*  C     INTEGRATION POINTS USED IN THE ENVIRONMENT CALCULATION
00101     7*  C
00101     8*  C-----------------------------------------------------------------------
00101     9*  C
00103    10*        INCLUDE COMON
00110    11*        INCLUDE COMUNT
00112    12*        DIMENSION NIPT(60)
00112    13*  C
00112    14*  C ************************     NOSE MODEL     ************************
00113    15*        INOSE=0
00114    16*        IF (STRAN.LT.SP(2)) INOSE = 1                                    000081
00114    17*  C ***************************************************************** 000001
00114    18*  C                                                                     000001
00116    19*        FACTOR = 1.                                                      000007
00117    20*        NSM1 = NS-1                                                      000011
00120    21*     50 NTT = 1                                                          000015
00121    22*        DSIOLD = 1.E10                                                   000016
00122    23*        DO 60 I=1,NSM1                                                   000025
00125    24*        NIPANG = 20.*ABS(THETSP(I)-THETSP(I+1))*FACTOR                   000031
00126    25*        DSSP = SQRT((RSP(I+1)-RSP(I))**2+(ZSP(I+1)-ZSP(I))**2)           000045
00127    26*        NIPDS = (200.*DSSP+.5)*FACTOR                                    000055
00130    27*        NIPODS = DSSP/(5.*DSIOLD)                                        000067
00131    28*        NIPT(I) = MAX0(1,NIPANG,NIPDS,NIPODS)                            000102
00132    29*        IF (I.EQ.1) NIPT(1) = MAX0(5,NIPT(1))                            000120
00134    30*        DSIOLD = DSSP/(NIPT(I)+1)                                        000131
00135    31*        NTT = NTT+NIPT(I)+1                                              000140
00136    32*     60 CONTINUE                                                         000146
00136    33*  C                                                                     000146
00140    34*        IF (NTT.LE.150) GO TO 70                                         000146
00140    35*  C                                                                     000146
00142    36*        FACTOR = .9*FACTOR                                               000151
00143    37*        GO TO 50                                                         000154
00143    38*  C                                                                     000154
00144    39*     70 J = 1                                                            000156
00145    40*        R(1) = RSP(1)                                                    000157
00146    41*        Z(1) = ZSP(1)                                                    000161
00147    42*        THETB(1) = THETSP(1)                                             000165
00150    43*        IPT(1) = 1                                                       000165
00150    44*  C                                                                     000165
00151    45*        DO 90 I=1,NSM1                                                   000177
00154    46*        DR = (RSP(I+1)-RSP(I))/(NIPT(I)+1)                               000203
00155    47*        DZ = (ZSP(I+1)-ZSP(I))/(NIPT(I)+1)                               000207
00156    48*        DTHET = (THETSP(I+1)-THETSP(I))/(NIPT(I)+1)                      000213
00156    49*  C                                                                     000213
00157    50*     80 J = J+1                                                          000220
00157    51*  C                                                                     000220
00160    52*        R(J) = R(J-1)+DR                                                 000222
```

```
00161    53*          Z(J) = Z(J-1)+DZ                                                    000226
00162    54*          THETB(J) = THETB(J-1)+DTHET                                         000231
00162    55*     C                                                                        000231
00163    56*          IF (J.LT.NIPT(I)+IPT(I)) GO TO 80                                   000234
00163    57*     C                                                                        000234
00165    58*          J = J+1                                                             000241
00166    59*          Z(J) = ZSP(I+1)                                                     000243
00167    60*          THETB(J) = THETSP(I+1)                                              000246
00170    61*          R(J) = RSP(I+1)                                                     000250
00171    62*          IPT(I+1) = J                                                        000252
00172    63*       90 CONTINUE                                                            000254
00172    64*     C                                                                        000254
00174    65*          J = 1                                                               000254
00175    66*          NTTM1 = NTT-1                                                       000256
00176    67*          DO 170 I=1,NTTM1                                                    000261
00201    68*          IF (I.EQ.IPT(J)) J = J+1                                            000265
00203    69*          MATL(I) = IMAT(J,1)                                                 000276
00204    70*          IF (I.LE.(IPT(J-1)+IPT(J))/2) MATL(I) = IMAT(J-1,1)                 000502
00206    71*       170 CONTINUE                                                           000315
00210    72*          MATL(NTT) = IMAT(NS,1)                                              000315
00210    73*     C                                                                        000315
00211    74*          S(1) = 0.0                                                          000317
00212    75*          SP(1)=0.                                                            000320
00213    76*          Z(1)=0.                                                             000321
00214    77*          J=2                                                                 000322
00214    78*     C                                                                        000328
00215    79*          DO 180 I=2,NTT                                                      000327
00220    80*          Z(I)=Z(I)-ZSP(1)                                                    000334
00221    81*          S(I) = S(I-1)+SQRT((Z(I)-Z(I-1))**2+(R(I)-R(I-1))**2)               000337
00222    82*          IF(I.LT.IPT(J)) GO TO 180                                           000352
00224    83*          SP(J)=S(I)                                                          000357
00225    84*          J=J+1                                                               000368
00226    85*       180 CONTINUE                                                           000365
00226    86*     C                                                                        000365
00230    87*          NTTM1=NTT-1                                                         000365
00231    88*          DRDS(1)=1.                                                          000370
00231    89*     C                                                                        000370
00232    90*          DO 150  I=2,NTTM1                                                   000377
00235    91*          RAT=(S(I)-S(I-1))/(S(I+1)-S(I))                                     000377
00236    92*          DRDS(I)=(RAT**2*R(I+1)+(1.-RAT**2)*R(I)-R(I-1))/(1.+RAT)/           000404
00236    93*         *(S(I)-S(I-1))                                                       000404
00257    94*       150 CONTINUE                                                           000424
00257    95*     C                                                                        000424
00241    96*          DRDS(NTT)=(R(NTT)-R(NTTM1))/(S(NTT)-S(NTTM1))                       000424
00241    97*     C                                                                        000424
00241    98*     C                          NOSE RADIUS CALCULATIONS                      000424
00242    99*          SX = Z(1)                                                           000432
00243   100*          SX2 = Z(1)**2                                                       000434
00244   101*          SXY2=SX2+R(1)**2                                                    000436
00245   102*          SXY2X = (SX2+R(1)**2)*Z(1)                                          000442
00246   103*          FNUM = 1.                                                           000444
00247   104*          DO 110 I=2,NTT                                                      000451
00252   105*          XY2 = Z(I)**2+R(I)**2                                               000451
00253   106*          SX = SX+Z(I)                                                        000457
```

```
00254    107*          SX2 = SX2+Z(I)**2                                                  000462
00255    108*          SXY2 = SXY2+XY2                                                    000466
00256    109*          SXY2X = SXY2X+XY2*Z(I)                                             000470
00257    110*          FNUM = FNUM+1.                                                     000474
00260    111*          IF (THETB(I).LT.,00139) GO TO 120                                  000477
00262    112*        110 CONTINUE                                                         000506
00264    113*        120 DENO = SX**2-SX2*FNUM+1.E-10                                   000506
00265    114*          BSH = (SX*SXY2-SXY2X*FNUM)/DENO/2.                                 000514
00266    115*          CSH = (SX2*SXY2-SXY2X*SX)/DENO                                     000524
00267    116*          B2MC=BSH**2-CSH                                                    000533
00270    117*          IF(B2MC) 95,94,96                                                  000536
00273    118*         94 RN = 100.                                                        000541
00274    119*          GO TO 130                                                          000543
00275    120*         95 WRITE(6,98) B2MC,BSH,CSH,DENO,SX,SX2,SXY2,SXY2X,FNUM             000545
00310    121*         98 FORMAT(/6H B2MC=E12.5,2X5H BSH=E12.5,2X5H CSH=E12.5,2X6H DENO=E12.  000562
00310    122*           *5,/6H   SX=E12.5,2X5H SX2=E12.5,2X5HSXY2=E12.5,2X6HSXY2X=E12.5,2X,  000562
00310    123*           *6H FNUM=E12.5/)                                                  000562
00310    124*     C                                                                       000562
00310    125*     C     **** USE MINIMUM NOSE LOGIC WHEN B2MC IS NEGATIVE **************  000562
00311    126*           RN=0.144*SIN(THETSP(2))/RUCH(2)                                   000562
00312    127*           RN=PT2*RN**2/FT                                                   000570
00313    128*           WRITE(6,97) RN                                                    000574
00316    129*         97 FORMAT(36H   MINIMUM NOSE RADIUS CONSTRAINT ON,10X,4HRN =,1PE11.4)  000602
00317    130*           GO TO 130                                                         000602
00320    131*         96 RN=SQRT(B2MC)                                                    000604
00321    132*        130 CONTINUE                                                         000610
00321    133*     C                                                                       000610
00321    134*     C     CALCULATE KSHOLD .....................                            000610
00322    135*           DO 500 I=1,NTT                                                    000610
00325    136*           J=NTT-I                                                           000614
00326    137*           IF((THETB(J)-THETA-DSHANG),GE.0.) GO TO 501                       000620
00330    138*        500 CONTINUE                                                         000630
00332    139*        501 KSHOLD=J+1                                                       000630
00332    140*     C                                                                       000630
00333    141*           RETURN                                                            000632
00334    142*           END                                                               000665
```

```
00101      1*          SUBROUTINE XSOLVE(X,Y,YGIVN,NCOUNT,XLO,YLO,XHI,YHI)
00101      2*    C
00101      3*    C-----------------------------------------------------------------------
00101      4*    C
00101      5*    C     THIS ROUTINE IS USED IN ITERATION FOR X WHICH SATISFIES THE
00101      6*    C     EQUATION Y = F(X) WHEN Y = YGIVN
00101      7*    C
00101      8*    C-----------------------------------------------------------------------
00101      9*    C
00101     10*    C     NOTE*  A GOOD INITIAL GUESS IS ESSENTIAL FOR THE SOLUTION.
00101     11*    C
00101     12*    C     *** INPUT ***
00101     13*    C     X =       AN ESTIMATED VALUE OF THE SOLUTION
00101     14*    C     Y =       CALCULATED FROM Y = F(X) IN THE CALLING ROUTINE
00101     15*    C     YGIVN =   THE VALUE OF Y FOR WHICH THE X VALUE IS BEING SOLVED
00101     16*    C     NCOUNT = A COUNTER WHICH MUST BE 1 WHEN XSOLVE IS FIRST CALLED
00101     17*    C
00101     18*    C     *** OUTPUT ***
00101     19*    C     X =       A VALUE OF X WHICH MORE CLOSELY SATISFIES THE EQUATION
00101     20*    C                 YGIVN = F(X)
00101     21*    C     XLO,YLO,XHI,YHI = THE COORDINATES OF THE TWO POINTS WHICH ARE
00101     22*    C                       CONNECTED BY A STRAIGHT LINE TO SOLVE FOR X
00101     23*    C
00103     24*          IF (NCOUNT-2) 10,20,30
00106     25*       10 XLO = X                                                    000003
00107     26*          YLO = Y                                                    000005
00110     27*          X = XLO+ABS(.011*XLO)                                      000007
00111     28*          NCOUNT = 2                                                 000013
00112     29*          RETURN                                                     000015
00113     30*       20 XHI = X                                                    000021
```

```
00114    31*          YHI = Y                                                    000022
00115    32*          X = (YGIVN-YLO)/(YHI-YLO)*(XHI-XLO)+XLO                    000024
00116    33*          NCOUNT = NCOUNT+1                                          000034
00117    34*          RETURN                                                     000037
00120    35*       30 DYLO = YLO-YGIVN                                           000043
00121    36*          DYHI = YHI-YGIVN                                           000045
00122    37*          IF (DYLO*DYHI) 40,40,70                                    000050
00125    38*       40 IF (Y-YGIVN) 60,50,50                                      000053
00125    39*     C                                                              000053
00125    40*     C     YLO AND YHI STRADDLE YGIVN WITH YLO CLOSER TO YGIVN      000053
00125    41*     C                                                              000053
00130    42*       50 XHI = X                                                   000057
00131    43*          YHI = Y                                                    000061
00132    44*          GO TO 100                                                  000063
00132    45*     C                                                              000063
00132    46*     C     YLO AND YHI STRADDLE YGIVN WITH YHI CLOSER TO YGIVN      000063
00132    47*     C                                                              000063
00133    48*       60 XLO = X                                                   000065
00134    49*          YLO = Y                                                    000066
00135    50*          GO TO 100                                                  000070
00136    51*       70 DYLO = ABS(DYLO)                                           000072
00137    52*          DYHI = ABS(DYHI)                                           000073
00140    53*          IF (DYHI.LT.DYLO) GO TO 90                                 000075
00140    54*     C                                                              000075
00140    55*     C     YLO AND YHI ON SAME SIDE OF YGIVN WITH YLO CLOSER TO YGIVN 000075
00140    56*     C                                                              000075
00142    57*       80 IF (ABS(Y-YGIVN).LT.DYLO) GO TO 85                        000100
00144    58*          X = X+(XHI-X)/5.                                           000106
00145    59*          GO TO 200                                                  000113
00146    60*       85 XHI = XLO                                                  000115
00147    61*          YHI = YLO                                                  000116
00150    62*          XLO = X                                                    000120
00151    63*          YLO = Y                                                    000122
00152    64*          GO TO 100                                                  000124
00152    65*     C                                                              000124
00152    66*     C     YLO AND YHI ON SAME SIDE OF YGIVN WITH YHI CLOSER TO YGIVN 000124
00152    67*     C                                                              000124
00153    68*       90 IF (ABS(Y-YGIVN).LT.DYHI) GO TO 95                        000126
00155    69*          X = X-(X-XLO)/5.                                           000133
00156    70*          GO TO 200                                                  000140
00157    71*       95 XLO = XHI                                                  000142
00160    72*          YLO = YHI                                                  000143
00161    73*          XHI = X                                                    000145
00162    74*          YHI = Y                                                    000147
00163    75*      100 X = (YGIVN-YLO)/(YHI-YLO+1.E-10)*(XHI-XLO)+XLO             000152
00164    76*      200 CONTINUE                                                   000165
00165    77*          NCOUNT = NCOUNT+1                                          000166
00166    78*          IF(NCOUNT.LE.100) GO TO 300                                000167
00170    79*          WRITE(6,250) X,Y,YGIVN,NCOUNT,XLO,YLO,XHI,YHI              000172
00202    80*      250 FORMAT(1X,10(1H*),'XSOLVE  X,Y,YGIVN,NCOUNT,XLO,YLO,XHI,YHI'/11X,
00202    81*     *3E12.5,I5,4E12.5)                                              000207
00203    82*          STOP                                                       000207
00204    83*      300 CONTINUE                                                   000212
00205    84*          RETURN                                                     000212
00206    85*          END                                                        000354
```

REFERENCES

1. User's Manual, "Aerotherm Real Gas Energy Integral Boundary Layer Program ((ARGEIBL)," Aerotherm Report UM-75-69, December 1975.

2. User's Manual, "Boundary Layer Integral Matrix Procedure Version C (BLIMPC)," Aerotherm Report UM-70-20, June 22, 1970.

3. Tong, H., Suchsland, K.E., Murphy, A.J., Kwong, K.C., Lee, K., Chu, E., "Graphite Performance Prediction Program, Volume II — Applicability of Reentry Technology to Rocket Nozzle Design," AFRPL TR-77-59, November 1977.

4. Abbett, M.J., Dahm, T.J., Brink, D.F., Rafinejad, D., Wolf, C.J., "Passive Nosetip Technology (PANT II) Program, Volume II. Computer User's Manual: Abres Shape Change Code (ASCC)," Aerotherm Report 76-224, October 1976.

5. "ICRPG Turbulent Boundary Layer Nozzle Analysis Computer Program," July 1968, Pratt & Whitney Aircraft.

6. Dahm, T.J., Cooper, L., Rafinejad, D., Youngblood, S.B., Kelly, J.T., "Passive Nosetip Technology (PANT II) Program, Volume I. Inviscid Flow and Heat Transfer Modeling for Reentry Vehicle Nosetips," Aerotherm Report 76-224, October 1976.

7. Lees, L., "Convective Heat Transfer with Mass Addition and Chemical Reactions," Combustion and Propulsion, Third AGARD Colloquium, Pergamon Press, New York, March 1958.

8. Jackson, M.D. and Baker, D.L., "Surface Roughness Effects, Part I, Experimental Data," Interim Report, PANT Program, Vol. III, SAMSO TR-74-86, June 1974.

9. Headzer, J., Moffett, R., and Kays, W., "The Turbulent Boundary Layer on a Rough, Porous Plate: Experimental Heat Transfer with Uniform Blowing," Report No. HMT-18, Stanford University, May 1974.

10. Reda, D., "Compressible Turbulent Skin Friction on Rough and Rough/Wavy Walls in Adiabatic Flow," NOL Technical Report NOLTR 74-34, Naval Ordnance Laboratory, February 1974.

11. Persh, J., "A Procedure for Calculating the Boundary Layer Development in the Region of Transition from Laminar to Turbulent Flow, NAVORD Report 4438, March 1957.

12. Dahm, T.J., "Interim Modeling of Boundary Layers for Shape Change Codes," Interoffice Memorandum, Aerotherm Division/Acurex Corporation, September 4, 1975.

13. Murphy, A.J., Chu, E., Kesselring, J.P., "AFRPL Graphite Performance Prediction Program, Volume I. Recommendation for a Standardized Analytic Procedure for MX Nozzle Throat Recession Calculations," Aerotherm Report 75-143, May 1975.

14. User's Manual, "Aerotherm Chemical Equilibrium Computer Program," Aerotherm Report UM-75-68, December 1975.

15. Tong, H., Suchsland, K.E., Murphy, A.K., Kwong, K.C., Lee, K., Chu, E., "Applicability of Reentry Technology to Rocket Nozzle Design, Volume II," Aerotherm Report TR-77-59.

16. Personal Communication between Henry Tong, Kai Kwong of Aerotherm and Philip Thomlinson, Joseph Koo of ARC.